MINING ENGINEERING

SEPTEMBER 1949

Incorporating
MINING and METALLURGY
MINING TECHNOLOGY
COAL TECHNOLOGY

MINING ENGINEERING

VOL. I NO. 9 SEPTEMBER 1949

In This Issue

Front Cover—Mechanized coal mining pictured at its best—in Leisenring #2 mine of U. S. Steel's H. C. Frick Coke Co., near Uniontown, Pa. Seen top-cutting into rich Pittsburgh vein of bituminous coal is universal cutting machine which slices nine feet deep into thick deposit. Machines operate at all angles, are used to cut top, bottom, and sides; are handled by two men. Runners become so adept at handling these machines that it is often said jokingly that they can cut their initials in the face.

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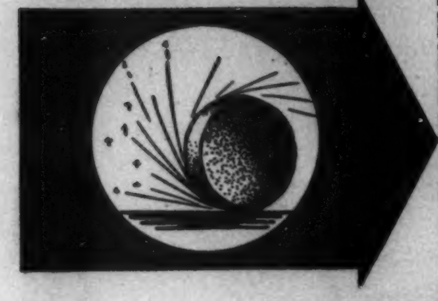

ABRASION

COSTLY WEAR FACTORS IN MILLING COUNTERED BY AMSCO® ALLOY STEELS

AMSCO STANDARD MANGANESE STEEL

"The toughest steel known" resists abrasion well under severe impact. Here's a service comparison of liners in a Colorado gold mine.

MATERIAL	TONNAGE GROUND
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For greater wear resistance than standard manganese steel . . . and to withstand shocks equally well.

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Standard manganese steel	6 mo.	17,256
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AMSCO CHROMIUM-MOLYBDENUM STEEL

Where impact resistance is secondary to extreme abrasion resistance, use Amsco uniform analysis "chrome-moly."

Material	Cost per Ton Milled
Standard manganese steel	.007405
AMSCO chromium-molybdenum steel	.006839

In your grinding mill two powerful forces of wear are always there . . . impact and abrasion. The extent to which each of these forces is present depends on a number of factors that vary with every mine. Among these factors are: type and condition of ore, size and speed of mill, size and total load of balls or rods, and design of liner.

It is in the correct weighing of all these factors that our experience added to yours can be of tremendous service. As a result of Brake Shoe research and development, we can recommend the particular alloy to use for all of the internal castings of your mill . . . to give optimum resistance to impact or abrasion (according to grinding conditions) and thereby greater tonnage before replacement is necessary. Amsco now offers mill parts such as liners, grates, and feeder lips in a range of alloy steels to meet most combinations of impact and abrasion. The case histories of liners listed here show typical results when Amsco recommended steels are used.

All uses for Amsco castings in mines and quarries are described in Bulletin 743M

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AMERICAN MANGANESE STEEL DIVISION

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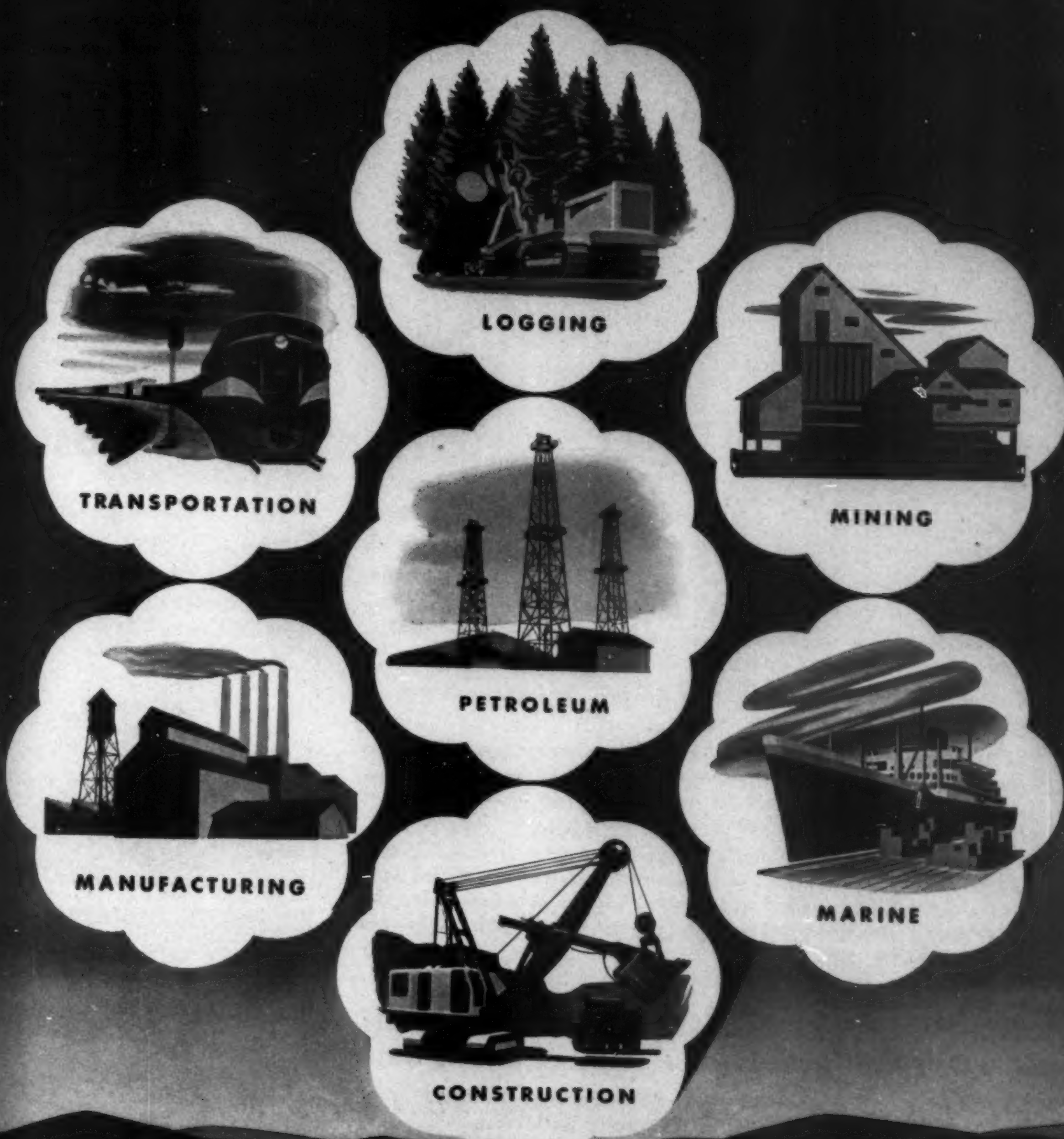
LOGGING
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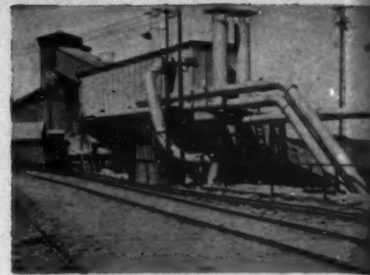
MARINE
CONSTRUCTION

Norblo

AUTOMATIC
Bag Type
Dust Collection



. . . for Star Performance at Low Cost

1. Basic unit compartment houses 78 cylindrical cloth bags — fully distended by upward inside air flow.

2. Shaking and cleaning involves only one compartment at a time, and only a few seconds out of each hour of operation.

3. Variable timing of cleaning cycle according to dust load insures constant volume of air handled and of dust collected.

4. During shaking period air flow is reversed, loosening dust and accelerating its descent into the hopper.

5. Any compartment may be cut out of operation for repair (from the clean air side) with all other compartments continuing in operation. Adjustment of shaking timer for dust loading can be made in a few minutes without shutting down.

Norblo equipment is completely designed and fabricated in our own shops and sold on the basis of guaranteed performance. If you need dust collection for production, for salvage, for good housekeeping ask Norblo engineers what they can do for you. Let us send you Norblo Bulletin 162-4.

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Norblo Centrifugal and Hydraulic Collectors
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- ★ **Greater Power and Efficiency**
- ★ **Simpler Operation**
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Left, JOY AW-80 Air Winch, a compact, rugged, flexible hoist for every small job. Weighs only 85 lbs., will lift 500 lbs., is powered by reversible piston-type motor.

JOY C-111 heavy-duty Shaft Hoist, with a 50 H.P. slip ring motor. Can be diesel-driven if desired. Lifts 5000-6000 lbs. at speeds up to 300 ft./min.

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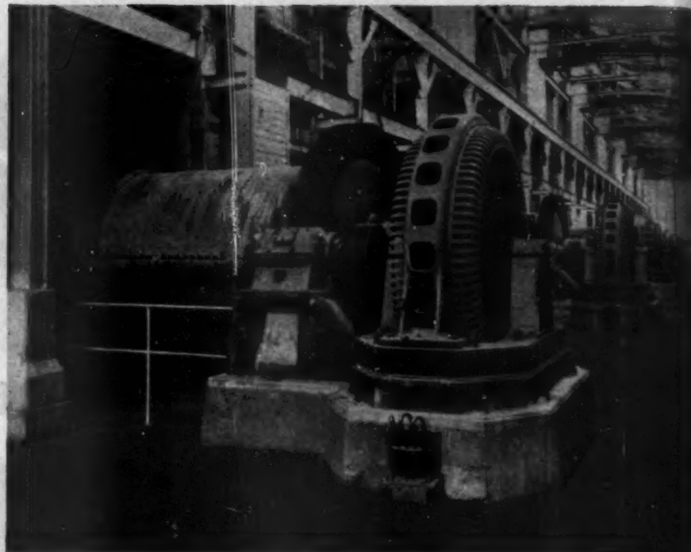

You Can Convert a Trunnion Overflow Ball Mill To MARCY Low Pulp Line Grate Discharge

The conversion to MARCY grinding may be expected to give a number of operational advantages, including the following:

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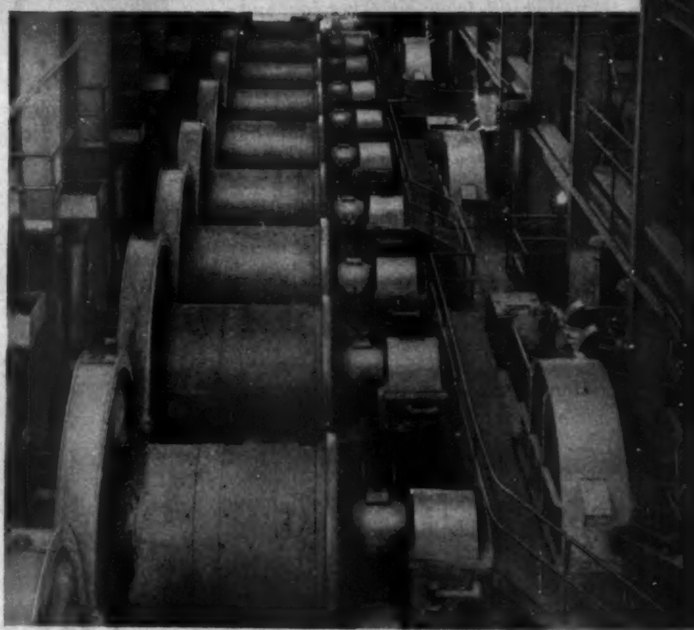
2. Low pulp line.
3. Rapid circulation of mill contents resulting in a minimum of overgrinding.
4. Much greater discharge-opening.
5. Quicker removal of finished product.
6. Higher pulp density, increasing grinding efficiency.
7. Less ball cushioning, greater impact drop.
8. Improved metallurgy in many flowsheets.

There are MARCY Mills for every flowsheet. "Mine and Smelter's" world-wide metallurgical experience is at your service. Your inquiry will have prompt, competent attention.



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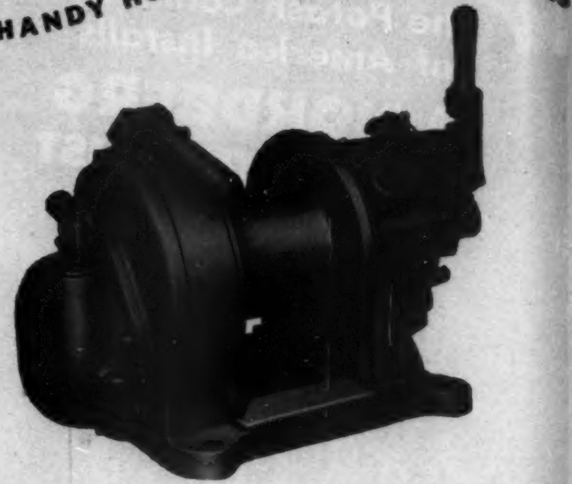
a new midget hoist FOR MINING



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The four cylinder piston-type reversible radial air motor equipped with safety type throttle supplies the extra power needed when the going gets tough. Wide band-type brake gives positive holding power and reversible motor permits lowering loads under power, while a convenient clutch lever located at the gear end of the hoist permits the drum to be disengaged for quickly pulling out cable.

Miners find the new BU ideal for moving equipment; hauling timber; handling shaker pans; spotting cars; hoisting drills, drill steel and other equipment between levels; hoisting and hauling pipe, etc. Call your Ingersoll-Rand branch office today for complete details and a convincing demonstration. Our Air Power Specialists are ready to show you how I-R Air Powered Equipment enables the miner to do more work with less effort.

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Manufacturers' News

William J. Weslow was appointed utility supervisor of *Diamond Products, Inc.*, Elyria, Ohio, on June 1. The firm manufactures core, bits, casing bits, reaming shells and other equipment used in the mining industry.

General Refractories Co. of Philadelphia has announced the appointment of *Harry T. Graham* as assistant general sales manager.

Edward J. Burnell, vice-president, general sales manager, and director of Link-Belt Co. in Chicago, died on July 22 at his home in Winnetka. Mr. Burnell had served the Company in many important capacities in engineering, sales and plant management. During the war he had served on the advisory boards of the machinery branch, WPB, the Chemical Corps, and as a consultant with the RFC.

Matthew W. Delehaunty has been named district sales manager for the Pittsburgh branch of United States Rubber Co.'s mechanical goods division. He will direct all Pittsburgh branch sales of hose, conveyor belts, and other industrial rubber products.

The Westinghouse Electric Corp. has announced three executive appointments in its industrial products division. *Tomlinson Fort* has become manager of the sales apparatus department, *Royal C. Bergvall* is engineering manager for industrial products, and *William W. Sproul* is sales manager for industrial products.

Worthington Pump & Machinery Corp. has announced four executive promotions. *Hobart C. Ramsey* is the firm's new president, succeeding *Clarence E. Searle*, who is now vice chairman of the board of directors. *Edwin J. Schwanhausser* has become executive vice president, succeeding Mr. Ramsey, and *John J. Summersby* is the new vice president in charge of sales.

Howard H. Weber is now general sales manager of the *United States Rubber Co.'s* wire and cable department. He will supervise sales of specialized electrical wires used in the mining, construction, and other industries.

Advertisers' Index

*Previous Issues.

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In applying for positions advertised by the service, the applicant agrees, if actually placed in a position through the service as a result of these advertisements, to pay a placement fee, established to maintain an efficient, nonprofit service.

All replies should be addressed to the key numbers indicated and mailed to the New York office. Include six cents in stamps for forwarding application to the employer and for returning when necessary.

A weekly bulletin of engineering positions open is available to members of the co-operating societies at a subscription of $3.50 per quarter or $12 per annum, payable in advance.

Men Available

Mining and Petroleum Geologist, B.S., 33, specialist reconnaissance exploration. Metal mining experience: iron, manganese, tin, gold, diamonds, copper, mica, vanadium - uranium. Foreign work Malaya, Philippine Islands, Argentina, China Tibet. Two years' petroleum exploration, subsurface and seismic, Gulf Coast and West Texas. Desires position manager exploration department or assistant to executive large corporation. Available immediately. M-453.

Executive Assistant, 31, B.S. in Geol. Eng. Experienced geology, mining; three years' superintendent earthmoving, heavy construction, overseas; four years' full charge business purchasing, selling, exporting machinery and metals, importing minerals. Night law student. Desires responsible position and opportunity; prefer New York City during completion law. M-454.

Mining Engineer, 30, married, veteran, B.S. Mining Engineering. Two years' varied experience in surface and underground surveying and mapping, ventilation and stope engineer. Desires position with small established mining operation. Presently employed. Available thirty days, prefer United States. M-455-473-E-9-San Francisco.

Mining Engineer, 34, married, two children, B.S. in Geology and Mining Engineering; 10 years' experience engineering and supervisory positions throughout coal fields of West Virginia and Ohio; considerable experience construction, mechanical loaders and trackless mining. Desires promising position with reputable firm; location immaterial. M-456.

Mine Superintendent, 40, experienced examinations, supervision, development. Graduate engineer and geologist, reading knowledge law. Supervisory experience in placer, gold and metal lode, and open-pit coal mining. Require adequate housing for family. Available 30 days. M-457.

Mining Engineer, A.B. B.S.E.M., married, no children. Six years' experience various phases and different types of mechanical coal mining. Supervisory positions held. Desires responsible position in management. Presently employed; available two weeks notice U. S. or Canada. M-465.

Production Engineer, 29, married, two children, B.S. mining engineering. Engineering and operating experience in both underground and open pit mining, including wage incentives and cost analyses. Desires responsible position in mining operations. Employed, available 30 days. M-462.

Mining Engineer-Geologist, 40, married, no children. M.Sc. in geology; 20 years' experience U. S. and Latin America. Thoroughly familiar most methods of underground mining, good reputation for labor relations and production. Broad training in mining geology valuation, etc.; fluent Spanish, good French. Location immaterial. Available immediately. M-463.

Mining Engineer, 36, married, one child. Twelve years' experience; engineering, practical work and supervising western metal mines. Engineering, Latin America. Speak Spanish. Prefer Latin America. Available thirty days. M-464-351-E-3-San Francisco.

Positions Open

Mining Engineer, young, with two to five years' experience, and with good knowledge of mechanized coal mining and knowledge of ore mining methods. Will function as assistant to executive in New York office and as liaison between mines and the office. Salary open. Location, New York Metropolitan Area. Y-1943.

Field Men, preferably mining geology graduates, for geophysical surveys. Must have magnetic and electrical experience on mining projects. Considerable traveling. Locations, United States and Canada. Y-2232.

Chief Engineer, 35-45, to take charge of all maintenance and mining operations for several widely scattered coal mines. Must have previous coal mining experience. Salary, $8000-$12,000 a year. Location, South. Y-2304.

Mine and Smelter Draftsman with considerable experience on the proc-

essing end of mining and smelting equipment. Salary open. Location, New York, N. Y. Y-2340.

Engineers. (a) Chief Draftsman for engineering room of about thirty men on the boards. Should be experienced in supervising men, and allocating work. Must have experience in design of rolling mills and auxiliary equipment for ferrous and/or non-ferrous metals. (b) Assistant to Supervisor of the rolling mill estimating department, experienced in layouts of general type mills for ferrous and/or non-ferrous metals. Should be capable of estimating weights and writing specifications for proposals. (c) Designers, Layout Men and Draftsmen for rolling mills and auxiliary equipment for ferrous and non-ferrous metals. Must have the above experience. Salaries open. Location, New York, N. Y. Y-2457.

Mining Engineer, graduate, to instruct mine surveying, mining and prospecting, elementary mineralogy, mineral dressing laboratory. Prefer man with experience in West; for Pacific Coast University. Position starts September 15, 1949. Write giving full experience record, education, etc. Y-2479S.

Field Engineer, mining graduate, with stripping or other earth-moving experience, to supervise and lay out shovel and other excavating schedules, etc. Salary, $3600-$4200 a year. Location, West Virginia. Y-2519.

Stratigrapher, with Ph.D., who has specialized in stratigraphy, to teach historical geology. Salary, up to $4500 for nine months, depending on experience. Location, Missouri. Y-2524-R-5724.

Mine Superintendent, 25-40, for gold field operations in hard rock. Must have at least five years' experience in mining in South America. Prefer married man. Salary, to $10,000 a year. Y-2613.

Instructor or Assistant Professor, mining graduate, to teach courses in mine design, mining methods, coal preparation, mine ventilation and mine surveying. Salary, $3800 for nine months, with a B.S. degree. $4100 with M.S. degree and at least four years' professional experience. Location, South. Y-2624.

Engineer with experience in manganese mining, to go to Turkey to organize the exploitation of certain mines and instruct those in charge of mines which are now in production. Temporary. Y-2640.

Sales Engineer to contact the steel refractory and abrasive industry for the sale of ores. Base salary, plus commission, plus expenses. Location, New York, N. Y. Y-2666.

Mining Engineer, experienced in driving tunnels in hard rock in connection with mining anthracite coal. Four year contract. Salary open. Location, Turkey. Y-2671.

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This Month . . .

To accompany September's bracing breezes, **Mining Engineering** presents this month a brand new face, three new departments—and, wonder of wonders for a monthly magazine—a "scoop."

Our new big-picture cover is the answer to many a reader gibe that the similarity of our covers each month rendered them indistinguishable. We hope, also, that it will prove more decorative, and that Mining Engineering will grace more magazine racks in well-appointed living rooms!

Our contents page is now a lot easier to find in its new position just inside the front cover.

The Mining Engineering reporter makes his first appearance in this issue and he will provide a monthly news flash of the latest information that the informed mining engineer will want to know. Following the Editorial, there will appear our monthly business summary. Thus the keynote is timeliness, bringing you the latest information about technical developments, and keen analyses of the general business picture.

Another new feature, "Your Engineering Profession," will keep you up-to-date on the organizations working for the advancement of the engineering profession.

Our profession, although one of the oldest, has a long way to go to catch up with the legal and medical professions as far as professional organization and recognition is concerned. The work that is going on toward building professional engineering standards is a matter of vital concern to all of us.

This month's "scoop" is an important message from Bureau of Mines' Director James Boyd, outlining the current reorganization of the Bureau. (See p. 40.)

Wherever you are, whatever your work, our new and improved **Mining Engineering** will keep you well-informed about Washington and the West, and about developments in stopes and conference rooms from Berlin to Butte.

We're easier to read this month. Some complications in the page numbering have been smoothed over, and the numbers are now consecutively run through the Feature Section and the AIME News departments. All the departments and advertisements formerly run in the back of the book are now up front for easy reference.

When you get to that article by Huff Wagner on **percentage depletion for mining,** don't pass it up because you don't compute the federal taxes for your company. In describing the situation as it is at present, Mr. Wagner also points out where clarification of the law is needed. Did you know that although you might be mining a metallic ore, magnesite for instance, you may not be entitled to a metal-ore percentage depletion deduction if your concentrate is not used as a metal product? Did you know that your transportation costs from mine to mill, if over a certain distance, cannot be charged as an operating expense when computing depletion? These are just a few of the interesting and important points that Mr. Wagner covers.

Anton Gray has prepared an interesting paper on the **possibilities and costs of methods of mineral discovery** for the United Nations Conference on the Conservation and Utilization of Resources, Aug. 17 to Sept. 6, which we bring to you in this issue. Mr. Gray shows how our exploration methods are keeping up with the problems created by the depletion of our easy-to-find ore bodies.

Northwest Magnesite has been able to cut cost by improved methods, mechanization of their quarries, and a new flotation and heavy-media plant. Howard Ziebell, manager of the Company, tells the story in this issue.

. . . and every month

Mining Engineering is the only publication serving the mineral industry that presents each month the widely acclaimed technical articles (**Mining Transactions**) for which AIME is famous. This gives **Mining Engineering** high readership and reference value. You will want to keep these articles for thorough study and future reference.

Correction: On page 71 of this issue, which is part of the four pages devoted to the AIME Mid-Year Meeting announcement, the **AIME ANNUAL BANQUET** was erroneously listed for Wednesday evening, Sept. 28. Actually, the Banquet will be held on **Tuesday evening, Sept. 27.**

** The steel ingot rate was advanced in the third week of August to 83.5 percent of rated capacity. The increase in steel output at a time when a decline had been expected by some officials has strengthened the market for raw materials for those products that go into steelmaking.

* Earl R. Muir, president of the Louisville Trust Co., told the Senate Banking Committee: "I don't think we're in a depression. It is a fine period of readjustment. You can't have a depression when you have 175 billion dollars in expendable money in the hands of millions of people. They hold it in the form of government bonds and building loans etc. When they see there is no further decline in prices there will be a resumption of spending.

* Senator O'Mahoney's mining incentive bill (S.2105) was reported ready for the Senate on Aug. 23. The amended and revised bill provides mandatory aid for small mining operators producing lead, zinc, or copper which does not exceed an average of 100 tons per month.

* Nicolaas C. Havenga, finance minister of the Union of South Africa, is here to encourage the flow of American investment capital to his country. He pointed out that as long as capital was forthcoming from England and the Continent, America enjoyed a profitable trade, but that stream no longer flowed so freely.

* Paul G. Hoffman, ECA head, says Marshall plan nations must fulfill their pledges of mutual economic aid. He urges that Europe's tariffs be cut on a substantial number of commodities. He stressed sound basic conditions, specifically big crops, as cure for Europe's troubles rather than currency devaluation. In England he was evasive about rumors of Anglo-U.S. economic union.

* The report of the Kennecott Copper Corp. and its subsidiaries covering the first half of 1949 disclosed that earnings for the first half of this year were less than half that shown in the initial six months of 1948.

* A new method of detecting and measuring radioactivity has been invented by three scientists of the University of Manitoba. Described as a "portable ray spectrometer", the instrument is undergoing field tests at the Nisto Mines property in the Black Lake uranium area, northern Saskatchewan. Engineers who have checked results obtained by the new instrument are enthusiastic about its possibilities.

* The Chilean government, acting against what was termed a widespread Communist revolutionary plot, ordered armed forces to take over mine areas. Communist leaders are being arrested in mining areas.

* Manganese can be recovered and reused from open hearth slag by crushing, calcining, grinding, jigging, and flotation. From this series of treatments an 80 percent manganese-iron alloy is recovered. A firm of consultants announced that $23 worth of manganese and iron per ton of slag can be recovered for an outlay of $13.

* The bureau of Mines announced that the nations bituminous coal mines have completed their five safest months in history.

* The official silver price was up ½ cent on Aug. 23 to 72 cents. This is the first change in silver price since February.

2 Things to Consider in Buying Grinding Mills...

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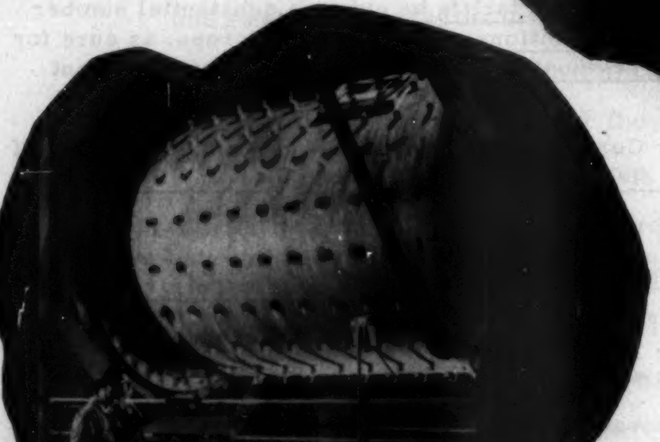

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Crusade Without Compromise

ENGINEERS are traditionally unselfish in the pursuit of their profession and, in the mining business, they are traditionally supporters of free enterprise. Yet, today, there are forces abroad which are balancing a desire for personal gain against duty to the public, sometimes in opposition to these avowed traditions. It is indeed difficult to decide when our marginal mines should be protected by tariff, whether or not and to whom subsidies should be paid, and whether gold should be on a free market, for good arguments can be offered pro and con. But these issues cannot be decided without more thought on fundamental principles. What will the effect of such changes be on the public? How far into the roots of worn-out mines can we go in the interest of conservation? Perhaps we will create a whole new set of marginal mines.

Basically these issues should be decided by the mining profession and not by the politicians. Engineering can set the dividing line between ore and waste. If given the opportunity it will shave this line closer and closer to the host of barren rock as it has in the past. The battlefield of this cause is at the mine not on Capitol Hill. Human resourcefulness is forging ahead to open new ore bodies, to find extensions of old ones, and even to return to old workings to carry off what formerly was unprofitable. Take a look at San Manuel, Allard Lake, the Greater Butte project, and Noralyn to measure the strength of this resourcefulness. In the ubiquitous controversy between miner and custom smelter there is ample opportunity for improvement. These differences should be kept inside the family and small operators should be encouraged.

The minor issues must be swept aside because our strength must be conserved for other imminent battles. Revision of the mining laws must be spearheaded by our representatives. The tax laws must be changed to encourage exploration and venture capital. These are the crusades that will permanently aid the mining industry.

The mining profession supplies American industry with billions of dollars' worth of new materials every year from resources with which nature has richly endowed our country but these resources cannot be extended by subsidy legislation. Let our clarion trumpets marshal forces throughout the land for the real crusade for which we need not compromise our avowed tradition of unselfishness and freedom of enterprise.

It's Everyone's Business

TODAY, over half way through 1949, recovery in Western Europe looks less certain. The broad political lines of cooperation, which converged upon the Atlantic Pact, have emerged relatively unscathed from the Senate debate. The attitude of many Senators, however, has shown that not all American leaders are committed to the definite abandonment of isolation. At the same time, the American recession has set unforeseen obstacles in the way of world recovery, not only by causing a decline in American purchases abroad but by inducing many Congressmen to believe that economy in national expenditure must include sharp cuts in foreign aid. The grand strategy of the western world is thus now neither as clear nor as firm as it was a year ago.

The most ominous of the clouds on the horizon continues to be the British dollar crisis, which is becoming somewhat of a political football on both sides of the Atlantic. Fateful indeed will be the Washington meetings next week between American officials and Britain's Cripps and Bevin. The British don't have a plan of merit to conquer their export deficit. As for the Americans, it is likely they will hint tactfully—or not so tactfully—at the possibilities of devaluing the pound and retreating from Socialism. Mr. Cripps will be quick to defend Socialism and undoubtedly will show the following table from the **London Economist:**

EXPORTS AND IMPORTS BY VOLUME
First Quarter of 1949

	Exports	Imports	Export Index divided by Import Index
Belgium-Luxbg. . . .	114	97	*118*
Denmark.	84	107	*79*
France.	127	106	*118*
Norway.	91	109	*84*
Sweden.	65	103	*63*
Switzerland.	113	121	*94*
United Kingdom. .	156	82	*190*

His attitude certainly will be that Britain's current dollar difficulties are not related to the specific Socialist measures that have been taken and that a non-Socialist government would not have taken. The Americans are likely to remain quite unmoved, and a rather unhappy situation is in prospect.

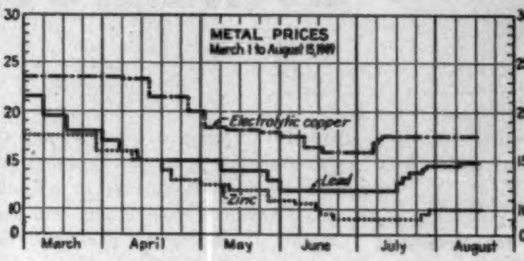
Elsewhere on Capitol Hill the O'Mahoney Bill to legalize freight absorption and the use of delivered prices by businessmen **acting independently**, has sped through both Houses, and is getting a little ironing out of differences in conference. Sponsored by two famous trust busters, it is designed to reassure businessmen who feared that the Supreme Court decision in the cement and, especially the rigid conduit case outlawed the absorption and averaging of freight costs, a very traditional and widespread practice. Industries such as steel, which abandoned delivered pricing after the cement decision (and when demand was so high that consumers could be induced to pay the freight charges themselves) are likely to resume absorbing freight charges where it is necessary to fight for orders. Recent increases in freight costs may, however, dampen their enthusiasm, and any return to an organized system of basing points is remote. Furthermore, as time progresses, the precise legal meaning of "acting independently" may provide the stuff of much expensive and exasperating litigation.

The O'Mahoney Bill, if it finally passes, will make a permanent amendment to the anti-trust laws. The greased way this Bill has slid through the Committees is due to the sponsorship of Senator O'Mahoney and Mr. Celler, both of whom have broken many a lance against the trusts. It might well be that their sympathies would lie on the other side but for the firm representations of beet-sugar growers and the infant chemical industries in Senator O'Mahoney's state of Wyoming and the strong case outlined to Representative Celler by the grocery chains. There is no denying that Representative Celler has been a busy man indeed, this hot summer in Washington. Part of the day it has been the O'Mahoney bill and the remainder of the day he has pushed hard on his bill to put additional "teeth" into the Anti-Trust Code.

Turning from Washington to the industrial midwest, the business community is deriving some crumbs of comfort from minor shifts in sentiment, but the crumbs are still small and quite crumbly. Nonetheless, the prevailing mood is in distinct contrast to the gloom prevailing no more than a few weeks ago.

Industrial production, though still patchy, is far more encouraging than in June. Production, as measured by the Federal Reserve Board's index, fell for eight consecutive months and hit a new low point in July. August likewise may show a moderate decline but there are high hopes that September will be the turning point. Expenditures for plant expansion have held up well in the first half of the year, according to Government estimates. Granted this is so, the sharp drop in the Reserve index indicated a very severe cutback in consumer spending. It is now popular to assume that with price cuts already made or about to be made, that there will be an increase in inventory accumulation and consumer spending over the Fall months which should stimulate industrial output. But as an offset, Government estimates indicate a moderate decline in plant expansion expenditures over the remainder of the year. Despite all the weighty pronouncements of economists and such, no one is yet sure whether the year end will witness a further sharp decline in business activity or a moderate recovery. Certainly the recent buoyancy in the two very sensitive economic barometers, steelmaking scrap and stock prices, is smoothing the furrows in many a brow. If this buoyancy persists the sound of laughter again may be heard in the Duquesne Club in Pittsburgh and the Brown Palace in Denver.

Price adjustments in finished and semifinished goods are still a matter of daily report. The Government, after eight years, has turned tin importation back to private concerns. Other nonferrous metals, after going through a drastic process of correction from mid-March onwards, have for some time been regaining some lost ground. Many users of these metals reduced their inventories to a dangerous level and were compelled to re-enter the market. Copper is now a little over 17½¢ a lb, compared with 16¢ in June; lead is 14¢ a lb



against barely 12¢ two months ago, while zinc has risen from 9¢ to 10¢ a lb. The initial rise has been attributed to purchases made by the Bureau of Federal Supply which, it is believed, has also entered into contract for delivery of metal within the next 12 months. However, the funds appropriated by Congress for stockpiling are limited, so that if the Bureau of Federal Supply buys heavily during the next six months it will once more be out of the market after the turn of the year.

Certainly, the significance of stockpiling operations from a market standpoint has often been greatly exaggerated. The Bureau of Federal Supply is expected to expend some $525 million in 1949-50, with the authorization to contract for a further $250 million of goods to be paid for in later years. There is, however, a motion in Congress to reduce the stockpile appropriation to only $200 million. The operations of the Bureau are, of course, necessarily secret, but by last December it had accumulated some $821 million of materials, of which $171 million represented new purchases and the remainder consisted of residue of the prewar stockpile and the transfer of surplus war material. The long-term objective is to amass a reserve of some 67 strategic commodities over a 10-yr period, having an ultimate value of some $3,500 million.

Labor's demands for further packets of money and security are likely to disturb the industrial picture for some time to come. A prolonged steel strike might well have sucked the American economy, now floating uneasily in economic crosscurrents, into a whirlpool of depression. It was the fear of being held responsible for this catastrophe that finally drove the bitterly protesting steel companies to accept a 60-day truce while the President's fact-finding board went to work. Among the consuming industries, the automobile industry, while talking of strikes, has been almost alone on the peak of industrial prosperity.

An individual today may be somewhat confused as to what his attitude toward the recession should be. Many an industrialist believes that depression talk is a boring-from-within technique devised by Stalin, whereas the American Federation of Labor has announced recently that the talking is all a clever move by the industrialists to kill off wage increases. Geography must have something to do with a particular person's opinion.

The accompanying map shows that it is only in predominantly agricultural states that unemployment has not increased since last January. According to the Federal Security Agency, nearly half of the country's 98 largest manufacturing areas have over 7 pct of their labor force unemployed, compared with the national average of 6 pct. There are a number of districts where unemployment is up to, or over, 12 pct and five of these "depressed areas" are in New England. This explains why Boston was the Secretary of Commerce's first stop on the tour of the nation which he made in order to find out where pump priming is most urgently needed. It also explains Mr. Dewey's recent announcement of plans to start a series of public works in New York State. The President has ordered all government hands to stand by at the pumps in areas of acute unemployment. If necessary, efforts are to be coordi-

Unemployment Increases Since January

nated by his chief assistant, Mr. John Steelman, and are to take the form of a concentration in those areas of all possible federal expenditure—military and relief purchases, public works and the like.

Appropriations to prime the pump are limited, however. If necessary, there may be enough water to dampen the present limited deserts of depression, but there is far from enough to prime all the pumps that would be needed if a drought really threatened the whole nation. Off in the wings, however, Senator Murray is touching up a permanent irrigation scheme. His Economic Expansion Bill of 1949 is intended to ensure a national income of $300 billion, with all the spending and taxing such an objective implies. So far it's just a cloud as big as a hand on the horizon but it's big enough already to make any number of people very grumpy indeed.

Exploration Methods Evaluated

By ANTON GRAY

In considering the possibilities and costs of discovering minerals by exploration, mineral occurrences may be classified roughly according to the size of the target they offer to the various methods that have been used to search them out. This classification is advantageous because the methods of search which might be expected to give results in one case may be totally inapplicable in others.

Mineral deposits for the most part have been found in groups, or districts, in which the individual deposits occur under the same general geological conditions and usually contain more or less the same metals. There are, also, what are apparently isolated deposits, although if the truth were fully known many of these probably would not be isolated. These districts, such as the Belgian Congo copper fields, the California Mother Lode, and the Linares lead district of Spain, form the first division of my classification. The second division is formed of the individual deposits of these districts, for example, Kambove mine in the Congo, the Kennedy-Argonaut vein in California, and the Cruz vein at Linares. The third division consists of the separate ore bodies that make up the deposits.

The possibilities of discovery, the costs, and the methods that would apply to exploration for new districts differ greatly from those that would apply to exploration for a mineral deposit within a known district. Searching for an extension to a known deposit, a new ore body, is still another and much easier problem and one being solved continuously by every mining company in the normal course of its development. Only a financially strong company can carry out efficiently the search for hidden deposits. Under present conditions, only a government can afford to carry out exploration for unknown mineral districts adequately.

Anton Gray is an AIME member and chief geologist for Kennecott Copper Corp. The Paper was presented at UNSCCUR under the title "Possibilities and Costs of Methods of Mineral Discovery."

These statements may seem to be in direct contradiction to the fact that all the known mineral districts and practically all the known mineral deposits were found by prospectors, usually men without great financial resources and often little technical ability, but who were prepared to risk their whole lives on the chance of finding a mine. Most of them failed; a small proportion succeeded, and their work forms the basis of the mineral industry of today. Now conditions have changed. The prospectors have penetrated and explored most of the accessible parts of the earth.

There may be mineral districts in the old rocks that are hidden under the sediments of the Mississippi Valley. There may be great mineral deposits under the swamps of the Amazon or beyond the shorelines on the continental shelves. No prospector could ever find these, no private company could afford to search for them with the methods and tools available today; yet with increasing geological knowledge and better tools they might be found. The cost of such exploration as this cannot now be estimated. Certainly it will be undertaken only by, or with the co-operation of, governments and only as metals become scarce and dear, for the work involved is tremendous, involving expensive research programs, geophysical and geochemical surveys over great areas, probably deep boring and the solution of deep-mining problems. In many countries it would require also drastic changes in the laws relating to mineral ownership.

Exploration for mineral deposits within known mineral districts is a less expensive and much easier problem, and one which is being solved with some success by mining organizations all over the world. The principal tool used in this work is the experience gained in the district being explored, combined with the recorded experience gained from other districts. The sum of all this experience, codified and explained in the light of our knowledge of the general sciences, constitutes the principles of what is usually called the geology of ore deposits. The valuable subsidiary tools, such as geophysics, geochemistry, aerial photography, and deep boring, all must be used in conjunction with and interpreted in the light of the known geological principles governing the occurrence of metaliferous ores. To estimate the cost of this work it is not sufficient to know that a ground magnetometer survey costs about $50 per mile of magnetic traverse while an airborne survey costs approximately $10 per mile and that deep boring may cost $5 or $10 per foot. The cost of finding a mineral deposit is the cost of all the time and work that leads to its discovery, and the largest factor in this cost is the skill with which the geological possibilities are estimated and the tools used. Usually it is necessary to make a good many unsuccessful efforts before a suspected

The high sensitivity airborne magnetometer, in its bomb-shaped plastic case, trails below the Aero Service's African Survey plane, over tailing piles of the gold mines of the Union of South Africa. This new device has served well in the search for new deposits.

mineral deposit is located and the cost of these unsuccessful attempts must also be charged against the deposit when it is found.

I am completely unable to estimate the cost of the exploration that has led to many of the presently successful mining operations. In some cases one must take into account the work of many prospectors, syndicates, and often several companies which failed before the present company, assuming none of the debts of the former unsuccessful attempts but building on the experience and knowledge provided by those failures, was able to make a profitable operation. If the costs of the unsuccessful operations had to be borne, many successful mines would not be operating. Such a history is not uncommon in the mining industry. It is the rule rather than the exception.

The mining companies with which I have experience attack the problem of the cost of exploration rather differently. An attempt is first made to value the known deposits of a district and from this to draw conclusions as to the probable value of any that may be found. A decision is then taken as to the expenditure that can be justified in the search for other and similar bodies, having in mind the probabilities of success or failure, as well as the financial capacity of the company undertaking the exploration. Having decided the amount that can be spent on this work, or risked on this work if you prefer, since there is always a large element of risk in the search for mineral deposits, the next step is to decide the most efficient program that can be financed within the limits set. The key to exploration success in the long run is to refrain from spending too much on any one venture.

A brief outline of the history of two successful exploration programs will, I think, illustrate at least part of what has been said and show what this work can cost. One of the most informative examples is the discovery and development of the Witwatersrand gold fields in the Transvaal. Gold was discovered about 1880 by prospectors in rocks exposed above ground. Once discovered, the gold-bearing rocks, which proved to be ancient sediments, were traced over forty miles by additional surface prospecting and shallow mining work. Then both on the eastern and western ends of the gold-bearing belt the sediments carrying the precious metal were lost under younger rocks. Over the years, deep drilling and ever deeper mining located and followed the extension of these so-called reefs to the east until some thirty years after the original discovery, what is now known as the "Far East Rand" had been more or less completely outlined and the reefs had been followed some sixty miles. Up to this point the discovery and development of the field had been accomplished by surface prospecting, mining, and deep drilling.

Geological studies indicated that at the western end of the field the reefs were cut off by faults. One section of

reef was located by drilling through some thousand feet of rock, much of which was cavernous water-bearing limestone. An attempt was made to sink shafts to the reef but the equipment available at the time was not equal to the task and the attempt was abandoned. It was not until about 1930 that engineering skill and equipment were developed to the point where another attempt was justified, and this effort succeeded. Then, with mining possible, the problem was how to locate the gold reefs lying hidden still farther to the west beyond other faults.

This problem was finally solved by using the recently perfected magnetometer, which has since proved one of the most useful geophysical tools. By this time it was known that certain highly magnetic shale beds occur in the gold-bearing series of sediments and that if these could be traced, the gold-bearing reefs could be located. An extensive magnetometer survey was made of the country under which the reefs were thought to lie. After several years' work, it was thought that the position of the magnetic shales had been indicated with sufficient accuracy to justify drilling. This drilling was done and the reefs located. At the present time, fifteen years after this magnetometer survey was made, three mines are operating or developing on this so-called "Far West Rand." This discovery must be credited primarily to the development of the magnetometer as a precise instrument of geophysical surveying, but partly also to the geologists who pointed out the possibility of locating the reefs west of the faults and the engineers who solved the problems of deep mining in difficult ground. The exploration work alone, including 2000 miles of magnetic traverses and several deep boreholes, required six years and an expenditure of over $2,000,000. The deposits it was hoped might be found, of course, justified such expenditure.

One more illustration will show how the magnetometer has recently been further developed and its usefulness extended. Iron-titanium ore was discovered by prospectors on the north shore of the St. Lawrence River in Quebec many years ago. Recent technological advances have given added value to this ore, and a few years ago a search was undertaken for this material. The first step was a general reconnaissance, to decide from the geological evidence available which area offered most promise of a discovery. This completed, prospectors were sent in to comb an area of some 1500 square miles for surface exposures of the mineral, many of which were found. Now the problem was how to determine, quickly and accurately, the sizes of the deposits. Most of the rock of the area is covered by swamp and glacial drift but the ore, being slightly magnetic, can be followed by the magnetometer. To make a ground magnetometer survey would require several years and because of the rough terrain would be expensive, so the recently developed technique of flying the magnetometer in an aireplane was used. This work, 5000 traverse miles flown, was completed in two months at a cost of less than $100,000. The exploration, incidentally, was successful. A mine is now being developed after three years of geological work, geophysical surveying, and drilling that cost about $500,000. This expenditure also was well justified by the type of deposit being searched for.

It would seem almost certain that in the near future most of the new mineral resources brought in by discovery will be extensions of known deposits. Almost every operating mine is continually exploring its own ground and while in most cases the new ore is deeper and lower grade, and consequently more costly, the outlook is that for a generation or so it will replace the ore mined. Eventually the present mines must be worked out.

I believe that for some time at least the discoveries of new deposits may keep pace with the rate at which old mines cease to operate. New deposits in known districts must become more difficult and expensive to find, but search will be spurred by the inevitably increasing prices of the metals won. It is my own opinion that new deposits and extensions of old deposits found by improved exploration techniques probably will maintain an adequate supply of most metals for several generations at least.

A view of the Cliff ilmenite-hematite ore body at Allard Lake, the opening of which was speeded by magnetometer surveys.

What Is ECPD?

AS we know it today, the engineering profession is made up of autonomous professional societies each specializing in its own branch of engineering. Until fairly recently engineers and engineering societies in this country concerned themselves principally with new technologies and the mastering of older ones, and little attention was given to the economic and professional status of engineers. To engineers and to laymen, engineering as a profession was an amorphous entity with no method of certification, and few recognized standards or definitions of scope.

It became apparent to many that what was needed was nothing less than a "joint program" for "upbuilding engineering as a profession" and establishing recognized methods of certification. As a result of a joint program sponsored by the major engineering societies, ECPD, Engineers, Council for Professional Development, was organized on Oct. 3, 1932, and began its work of promoting the welfare of individual engineers.

The ECPD is a conference body which functions as a co-operating agency for the following eight national engineering organizations: American Society of Civil Engineers, membership, 25,041; American Institute of Mining and Metallurgical Engineers, membership, 18,976; The American Society of Mechanical Engineers, membership, 28,039; American Institute of Electrical Engineers, membership, 30,-911; The Engineering Institute of Canada, membership, 1,259; American Society for Engineering Education, membership: institutional 169, individual 5697; American Institute of Chemical Engineers, membership, 9056; and the National Council of State Boards of Engineering Examiners, membership: 51 member boards, 290 legally appointed board members, reporting approximately 135,000 legally registered or licensed engineers.

It is not an independent body but derives financial and personnel support, and administrative personnel, from constituent organizations. ECPD functions are promotional and exploratory. Its responsibility is the professional welfare of the individual engineer regardless of his specialized technical field.

The governing body of the ECPD is a council composed of 24 members, three from each sponsoring organization, and four ex-officio members who represent the four main ECPD committees of Student Selection and Guidance, Engineering Schools, Professional Training, and Professional Recognition. The council has two main functions: It explores professional questions and makes recommendations. ECPD recommendations go to the governing boards of sponsoring organizations who act on recommendations and administer recommended procedures through their own national and local groups.

One of the basic ECPD concepts is that there are four normal stages in the life of the engineer, in each of which the engineering profession has a responsibility. In the first or precollege stage, the profession must see that only those who are fully qualified should embark on the arduous course of engineering studies. In the second stage, that of undergraduate study, the profession must share with the colleges the responsibility for standards of engineering instruction. In the third stage, which begins when the young engineer enters industry, the profession must create the opportunities for further personal and professional growth; and in the fourth stage of full professional practice the profession must concern itself with the legal and professional standards by which the engineer becomes established and recognized. The ECPD constitution creates a standing committee charged with responsibility for each of the four stages.

By focusing the thinking of engineering societies on matters of common professional concern, ECPD has been setting the stage for eventual unification of the engineering profession. It has provided opportunity for leaders of the various branches of engineering to work together. This backlog of experience is contributing to the success of the Engineers Joint Council, the agency through which the Founder Societies and the AIChE work together on matters of economic import for engineers. Where ECPD is concerned with the individual welfare of engineers, the EJC is organized to represent the engineering profession in matters relating to sister professions, international relations, and government agencies.

There is ECPD work to be done in every industrial community. ECPD activities on the national level must be organized as community projects. If engineering is to grow into a proud and respected profession, individual engineers must contribute imagination and energy to maintaining high standards of engineering performance. With respect to the four cardinal tasks of the ECPD, the first question each engineer should ask himself is "Why should I not help?"

Here are some of the jobs to be undertaken.

(1) Help to organize a local ECPD Student Guidance Committee to co-operate with high school authorities in the job of helping boys in selecting a career. ECPD groups should talk to graduating students, explain the nature of engineering work and the qualities which bring success in it.

(2) Organize ECPD groups to study industry training programs, encourage co-operative evening study programs, and exchange of facilities. There is no reason why engineering staffs of one company should not support city-wide training programs co-ordinated with engineering registration requirements and sponsored by local industry and engineering schools.

(3) Organize ECPD groups to study engineering registration laws with the objective of encouraging greater uniformity among the states. Local ECPD committees must assume responsibility of evolving registration machinery which can become an important measure of professional recognition.

Although truck haulage is used by Northwest Magnesite Co., some ore is transported as much as 9 miles from quarry to millsite by Riblet cable trams.

Mechanization

by HOWARD A. ZIEBELL

THE Washington magnesite deposits, located in the hilly and mountainous northeastern part of Washington, occur as massive lenses in a sedimentary series made up of dolomite, shale, and quartzite, into which basic dikes have intruded. The ore pattern resembles a series of disconnected chain links extending approximately 25 miles in a southwest direction. Magnesite in this district is all crystalline and closely associated with dolomite, talc, serpentine, and basic dike rock. All deposits which have been developed are near the surface so that quarry-bench mining has been possible.

For over twenty years hand sorting magnesite ore at the quarry face was standard practice. Ore cars were hand trammed on 30-lb rail systems which led from the face to ore passes or raises for the magnesite ore and to the waste dumps for disposal of the rejected waste material. This system was somewhat modified by the use of Dempster Dumpster trucks. The ore was, however, still sorted by hand from the calcium and silica bearing waste rock. Power equipment, consisting of one ¾-yd electric shovel, was employed for stripping overburden from the ore.

The entire production of Washington deadburned magnesite is used for refractory purposes. Siliceous and calcium impurities must be kept to a minimum since they react as fluxes under the severe temperature and slagging conditions encountered in the modern furnace. For this reason mechanical mining was not practical until milling methods became sufficiently developed to successfully concentrate magnesite ore and reject the undesirable fractions.

Following the erection of the 300-ton flotation mill and the 3000-ton heavy-media separator, mechanization of the mining system was undertaken. This program required major changes in mining methods, transportation systems, and primary crushing installations. Power mining equipment was not only difficult to obtain during the war years, but also during the years immediately following the war. Some used gasoline-power equipment was purchased during this period until the new equipment was delivered. The new shovels now in use have 2½-yd buckets and are diesel powered. Euclid 10-yd capacity end-dump trucks have replaced the 3-yd gasoline-powered. The Euclid trucks all have 150-hp Cummins diesel motors.

The general mining system was not immediately changed after power shovels and trucks were put into service. Magnesite ore was still dumped into raises to the main haulage levels and taken to the mill by both battery and trolley locomotives. Quarry bench levels were still spaced at both 30 and 40-ft intervals. Primary drilling was entirely done with jackhammers. This practice was superseded with wagon-mounted drills which produce both horizontal and vertical holes to a depth of thirty feet. Most holes, however, are drilled to a depth of 24 feet which will make a twenty-foot level or bench. As many as nine hundred vertical holes have been fired at once for a primary shot. These vertical holes are spaced 5 to 5½ ft apart, depending upon the type of magnesite ore encountered. Detachable Timkin bits are employed in sizes ranging from 2 to 3 in. Tungsten-carbide detachable bits have been recently employed to advantage in the areas where harder ore is encountered.

After a short period of time it was found to be more economical to increase the truck haulage distance and abandon the ore transfer and locomotive haulage systems. The average truck haulage is

Mr. Ziebell, AIME member and manager of the Northwest Magnesite Co., Chewelah, Wash., presented this paper before the Third Annual Northwest Industrial Minerals Conference, Spokane, Wash., May 14, 1949.

Cuts Costs

Prior to the erection of this 300-ton flotation mill and a 3000-ton heavy media separator, the magnesite ore, used entirely for refractory purposes, was hand sorted at the quarry face.

approximately 2000 ft, however, ore has been successfully transported by truck a distance of 2.2 miles. All truck roads are laid out with grades not to exceed ten percent. Emphasis is placed upon keeping the roadways free from rocks and poor surfaces in order to secure the maximum truck and tire life.

After a relatively short period of time, it was discovered that some quarries showed a better production performance than others even though the general conditions appeared identical. Stop-watch studies soon pointed out the reason for these differences in performance. These studies brought into sharp focus the importance of proper truck and shovel co-ordination and cycling of operations. A few seconds lost on each truck cycle allowing the shovel to remain unproductive amounts to an appreciable tonnage in eight-hours time. The stop-watch studies were explained to the shovel operators, truck drivers, and foremen and their response was immediate co-operation.

In order to provide the maximum amount of shovel and truck-operating time, it was found to be desirable to have the trucks and shovels not only serviced and lubricated before the shift begins but the units should also be started. This is especially important during cold weather. A considerable amount of operating time can also be saved at quarries operating sixteen and twenty-four hours by lubricating the units during shift change and the noon hour.

During both primary and secondary blasting operations it is necessary to remove the equipment from the immediate blasting area. Secondary blasting accounts for a larger amount of lost operating time. In the larger quarries it is possible to have the shovel place the larger fragments of ore on the floor behind the shovel advance for the secondary miners. In small quarries where the working area is restricted this is not possible. The method found to be most practical is to load the large rock into trucks which deposit them on a floor or cleared area away from the shovel operation. This requires a double handling of the rock but it is more economical than moving the shovel out and waiting for the secondary miners. Two working faces are provided whenever possible in order to reduce lost operating time in the small quarries.

Primary crushers were all originally installed to crush hand-sorted rock. After power mining equipment was installed, it was soon discovered that the small crusher feed opening placed too great a burden on secondary miners. Grizzly bars were required over all crusher feeders to prevent the large ore pieces from reaching the primary crushers. This did not take the burden from the secondary miners but it did stop drilling and blasting operations at the crusher.

Careful studies over a considerable period of time were made as to the cost required for secondary miners to break a ton of ore which would pass a 14-in. grizzly. As a result of these studies, it was found to be of considerable advantage to install a 42-in. gyratory primary crusher. This crusher provides sufficient feed opening for all rocks passing through a 2½-yd dipper. This size crusher not only takes a major portion of the burden from the secondary miners, but also there is no longer any power mining interruption resulting from blocked grizzlies at this installation since no grizzlies are required.

Quarries too far removed from the mills for practical truck haulage are connected to the millsite by Riblet cable trams. The greatest distance now in operation is approximately nine miles over a rough and mountainous area. These trams have a capacity of one hundred tons per hour. Ample ore surge storage is provided between the quarries and the tramway to prevent lost operating time which might result from short interruptions in either operation. Approximately ten thousand tons of crushed-ore storage is provided between the gyratory installation and the tram loading terminal.

Conversion from hand mining systems to mechanization has made it possible to maintain reasonable operating costs in an era of rapidly rising labor costs.

U. S. Bureau of Mines Reorganizes

By James Boyd

THE Bureau of Mines for a number of years has been seeking additional ways and means of improving the efficiency of its operations and increasing its service to the public. It has become obvious that changes in the organization of the Bureau are essential to a more effective accomplishment of its functions and objectives. The old organization was defective in meeting current needs in that the Bureau's field activities were neither sufficiently co-ordinated with the national program nor were they particularly responsive to local needs of the mineral industries. Further, the traditional organization hampered the efforts of the Bureau to obtain, analyze and provide to the policy-making agencies of the Government essential information and advice in such a form that the requirements of domestic industry could be fully taken into consideration in the development of domestic and foreign policies. Consequently, the Bureau has now modified its organizational structure.

The new organization, which is designed to improve all these phases of the Bureau's work, attempts to delegate maximum responsibility for operations to experiment stations and offices in the field and to leave to the headquarters staff greater opportunities for planning and direction of the Bureau's program and their integration with the minerals activities of other agencies. The basic plan (see accompanying chart) establishes eight semiautonomous regions, one for Alaska and seven in the continental United States, each region to be headed by a regional director. These regional directors, representing the Director of the Bureau in their respective areas, will report to the Director in Washington and will be responsible for all Bureau activities in their respective jurisdictions. They will be in contact with the state officials in their regions, and will attempt to handle all problems of a local nature.

One of the most beneficial results to be expected from the reorganization of the Bureau's activities on a regional basis will stem from simplification of administrative procedure. Previously, even some of the most trivial administrative decisions had to be referred to Washington for action. In the past, each of the Bureau's five divisions maintained separate field offices reporting to the Division Chief in Washington with allotments of funds to each. This resulted in duplicate sets of books, often far out of time phase. Bureau staffs working in the same field offices received orders from separate individuals in far away Washington. Now the regional directors will have full authority to act. They will be provided with administrative assistants and will control the signing of contracts, the disbursement of funds, the accounting procedures, and personnel management, with only staff direction from the Washington office. It is felt that when the new system is fully established the technical employees will be relieved of administrative tasks and the administrative costs will be substantially reduced.

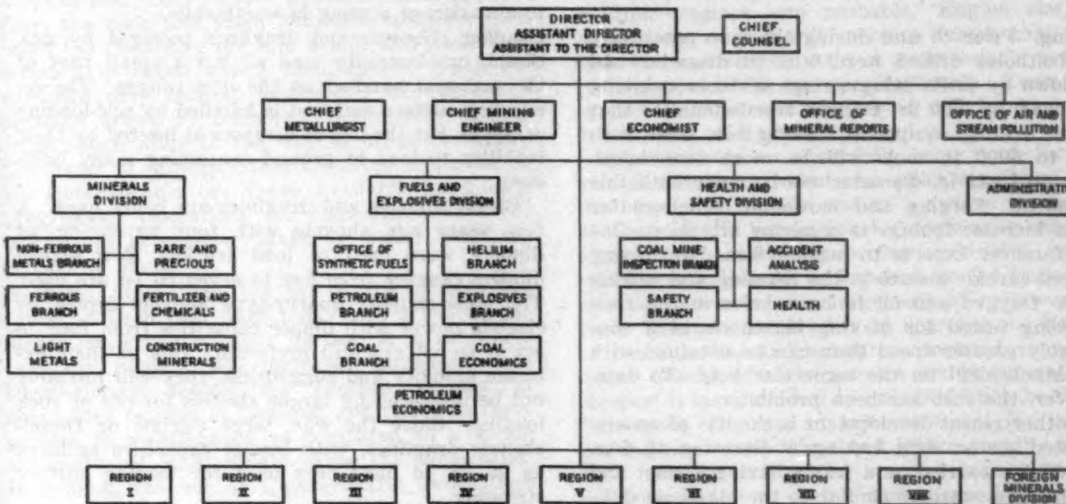
In Washington, the new organization will be staff only. The top technical experts will be relieved of the past burden of administrative tasks. They will be able to give full time to the consideration of responsibilities of the Bureau in such a way as to plan the research program in the direction of the greatest need. They will be better able to take part in interdepartmental discussions on policy matters, and to think through carefully the impact of legislation and policy discussions on mineral raw material availabilities and their effect on the domestic mineral industries and the mineral economy of the country as a whole.

The Washington headquarters has now been organized along line and staff functions. The fundamental operations are organized on a commodity basis, being entrusted to three main operations divisions: Fuels and Explosives, consisting of all solid, liquid, gaseous and synthetic fuels, and including the statistical and economic activities previously conducted by the Coal Economics Branch and Petroleum Economics Branch of the former Economics and Statistics Division; the Health and Safety (considered a commodity for organizational purposes), which remains unchanged from the old organization except for the addition of the Accident Analysis Branch; and Minerals, which includes the former Mining, Metallurgical, and Economics and Statistics Divisions, and will itself be subdivided in branches to handle ferrous metals, nonferrous metals, light metals and other commodity groupings.

With the Accident Analysis Branch now as an integral and functioning part of the Health and Safety Division, accident statistics will become so integrated with the work that we can measure more accurately the effects and progress of our activities in this field. The industry will be better

Jim Boyd, Director of Bureau, completes plans laid over a year ago for reorganization along military lines. New structure will cut red tape in Bureau aid to industry, will enable it to provide more information for policy-making government agencies, and will be cheaper to operate.

ORGANIZATION OF THE BUREAU OF MINES



able to find the weak spots in their own safety programs to the end that accidents can be further minimized in the mines.

Since all phases of fuel activities will be under the direction of the Chief of the Fuels Division, we should be able in the future to measure more accurately the interrelationship between the various energy producing industries. These industries in the future should be able to see more clearly where they should concentrate their energies and plan their programs to meet the public need. They have long since become dependent on Bureau statistics for many of their planning activities.

The Minerals Division is intended to produce for the mineral industries other than fuels the facts, statistics, and research results more in line with their needs than the relatively unco-ordinated results achieved when there were three divisions working separately in that field. We have come to find that the development of these programs is inseparable. Some of this type of direction has long been practiced in the fuels field, with the result that we are better informed and the Bureau's work has been better performed there than in the metals and nonmetallics field.

There are research activities which cut across all three commodity divisions, however, and they are to be co-ordinated by the three advisory positions of the Chief Metallurgist, the Chief Mining Engineer, and the Chief Economist.

In addition to the eight regions covering the United States and Alaska, there is established a Foreign Minerals Region, headed by a director who will carry on the fact-finding and analytical activities which are becoming more and more important to this country.

The initial stage of reorganization went into effect on September the first, but it will be several months before the final reorganization will be in full operation.

Range Mechanization Progresses

by JOHN S. HEARDING

ON the Minnesota Ranges, 600 million tons of material have been moved in the past three years to produce 172 million tons of direct-shipping iron ore. Increasing wage rates and cost of equipment and supplies, coupled with the larger amount of waste material to be moved in comparison with the quantity of ore make it imperative that the industry adopt all practices and methods which will enable it to move earth at progressively lower costs.

Drilling. Prior to and during the war practically all blastholes drilled were 6-in. in diameter and put down by drills using strings of tools weighing from 2000 to 3000 lb. Present trends indicate that heavier drilling equipment making 9-in. holes with 3000 to 6000 lb tools will be more economical. Holes up to 12 in. diameter will be made with this equipment. Forging and hardening practices for bits to increase footage is receiving attention. One manufacturer expects to market 9-in. bits having sintered carbide inserts in the reaming and cutting edges. Oxygen and oil to burn holes in the rock are being tested for making blastholes at a considerably greater speed than can be obtained with a blasthole drill on the same size hole. To date, however, the cost has been prohibitive.

Another recent development is the use of an air-operated piston drill having a diameter of 6-in. This drill is carried on a frame having a mast and caterpillar mountings similar to the blasthole drill. It drills holes of five or six-in. diameter using bits with four sintered carbide inserts in the shape of a cross. Cuttings are blown out of the hole with air. It is too early to predict how successful this machine will be.

Blasting. For blasting 25 to 30-ft ore banks only a slight displacement of the material is necessary, and to that end 6-in. holes varying in spacing from eighteen to 25-ft. are used over the iron ranges. A slow dynamite with wide spreading action heaves the material, which is shot at factors which fall between 0.35 and 0.22 pounds of explosive per cu yd. Many operators have successfully replaced high-nitroglycerin explosives with less expensive ammonia dynamites. Free running grades are frequently used in dry holes.

During the winter stripping season and subsequent to the removal of the glacial overburden, rock blasting is often necessary. This rock is chiefly taconite, an iron-bearing cherty formation, with a density in the neighborhood of 3.2. It is usually taken in lifts averaging 30 ft. but in removing taconite lenses, 10-ft. holes must often be used on ten to twelve ft. centers where 6-in. holes 25 to 35 ft deep are used, spacings vary from sixteen to 21 ft, the average being about 18 ft. Nine-in. holes are placed on 21 to 27 ft centers, and shooting factors vary between 0.50 and 1.00 pound of explosives per cu yd. Here also, as in ore, considerable saving has been made by the substitution of newer grades of explosives which replace the higher cost high glycerin types.

Primacord is used almost exclusively. It is a safe, quick, and convenient method of connecting holes. Plain primacord is used for trunk lines and either reinforced or wirebound for the down lines. The latter type is used where its added resistance to abrasion or cutting is worthwhile.

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Loading. Shovels and draglines powered by gas, diesel, or electricity load all but a small part of the material handled on the iron ranges. The remaining surface material is handled by self-loading scrapers, but the use of scrapers is limited by their inability to load in ground containing many boulders.

Bigger shovels and draglines are being used. A few years ago shovels with four to five-cu yd dippers were used to load trucks. Now shovel dippers ranging from five to seven cu yd are used. The close-coupled quarry-type shovels driven by electric power with dipper capacities from four to seven cu yd are still preferred. Due to their extreme mobility and ruggedness, they will probably not be displaced by larger shovels for ore or rock loading. Since the war, large electric or Diesel-electric draglines, with bucket capacities as large as 25 cu yd have been used for loading surface stripping.

Due to the continued rise in the cost of labor and supplies, some ore, which up to a few years ago had been considered undergound ore, can now be mined more cheaply by open-pit methods. The use of large draglines, will change still more underground ore into open-pit ore. The necessity for separating the ore into different grades does not permit the use of big shovels for loading.

There has been a constant effort by manufacturers to lessen the physical effort required by the operator of gas and Diesel excavators. Improved booster shoes and the used of hydraulic, compressed air, or vacuum-operated controls have served to accomplish this.

Most electric shovels and draglines on the iron range are equipped with "Ward Leonard" or "variable voltage control," which control has been modified by the rotating control, which eliminates most of the contractors formerly needed. The shovel or dragline also responds more quickly for the operator. It is therefore rapidly coming into general use for 4 cu yd or larger machines.

There is also a class of small gas and Diesel-

driven excavators used in "scramming" or clean-up operations on the larger mines. They range in size from ⅜ to 1½ cu yd and are used with various front-end combinations, such as shovel, dragline, or drag shovel. The drag shovel, or trench hoe, is an excellent tool for cleaning out deep narrow veins of ore. They remove as much ore as possible from the rock, and small hydraulic monitors then wash the remaining ore into sumps and piles from which it is loaded with a small shovel. Small excavators have entirely superseded the two-wheel scrapers drawn by tractors. "Scramming" operations began prior to the war in order to satisfy the terms of mining leases requiring shipment of all merchantable ore made available as mining progressed. Operations are conducted where the ore occurs in shallow banks or narow veins expensive to mine.

Haulage. Since 1939, the use of rail haulage has fallen off each year until today only a few of the larger properties continue its use. It is not likely that rail haulage will increase. Introduction of Diesel-electric locomotives effected savings of about fifty percent in fuel cost and thirty to forty percent in maintenance as compared to a steam locomotive of equal weight doing the same work. In general, the use of Diesel-electric locomotives has been limited to three percent grades, though it is possible to operate on five percent grades when necessary.

Thirty-cu yd air-dump cars transport waste and haul crude ore to the processing plants. By the use of low-alloy, high-strength steels a 25 percent reduction in weight has been effected. All cars have been equipped with roller bearings.

Today trucks of 22 and thirty ton capacity are the rule rather than the exception. Tire sizes are up to 18:00 x 24 and 18:00 x 32. Single drive axles are used on the 22-ton trucks, but the thirty-ton trucks may be had in either the single or tandem-drive axle. Struck measure capacity of the boxes for the 22 short ton trucks is 14.8 cu yd; for the thirty ton trucks it is twenty cu yd.

Early rubber-tired vehicles on the iron ranges were largely limited to the rear-dump truck. Then came side-dump semi-trailer units, having a struck measure capacity of 16 cu yd. Now bottom-dump semi-trailers are in service, the largest of which has a capacity of 25 cu yd and a payload rating of about forty short tons.

Supplementing the larger haulage units are small end-dump trucks varying in size from two to ten tons capacity, powered chiefly with gas engines. These units are used in the smallest pits and for "scramming" operations in the larger pits and move a considerable tonnage each season.

Vehicles with more powerful engines, or with multiple engines, are probable. Engine size or horsepower output will increase faster than vehicle size so that the ratio of gross vehicle weight to horsepower will be more favorable. Tests are in process now with engines of 550 hp installed in trucks of thirty-ton capacity.

Improvements are constantly being made by the manufacturers. A recent one, which may have far-reaching effect, is the use of a torque converter in place of the conventional transmission mechanism. If the converter proves successful, maintenance costs should be lessened as the transmission is the source of a large part of maintenance cost. The present trend is to decrease the length of truck hauls, and substitute inclined conveyor belts. Grades of seven percent are in general the steepest it is economical to use with truck haulage.

Conveyors. The use of belt conveyors for transporting ore in the mines has grown steadily since 1937. Trucks gather the ore and take it to the receiving end of the belt, from whence it is moved to the processing plant or shipping pocket. In this type of service, the belts are 30-in. wide, on 1800 ft centers, and travel at speeds up to 600 fpm.

The first steel-cord conveyor belt was installed in 1942. It was 1056 ft between centers and elevated the material 243 ft. The wartime demand for steel hampered construction of other steel-cord construction belts. Now several such belts with center distances up to 1610 ft and lifts up to 358 ft are in operation. During 1948 the first belt conveyor system to handle surface stripping was installed. It consists of several flights of 48-in. belt which moves the stripping about 6000 ft and deposits it, by means of a stacker conveyor, in a semi-circular dump about 150 ft high. A traveling hopper receives the output of a 25-cu yd dragline. The system was designed to handle 1000 cu yd per hour.

Other installations of similar design, although smaller in size, will be placed in operation within the next year, and there is little doubt that this method of transporting surface stripping will find greater use in the future.

Percentage Depletion for Mining . . .

. . . computations depend on some nebulous legal terms. If you have difficulty defining

"gross income"

↓

"net income"

↓

"the property"

↓

"a metal mine"

↓

as used in the Code, read this article for clarification.

by WM. HUFF WAGNER

COMPUTATIONS and allowances for mine depletion for Federal income tax purposes depend upon the meaning of certain terms in the pertinent provisions of section 114(b) 4 of the Internal Revenue Code. Unfortunately, but one of these terms is defined in the Code. Congress left it to the Commissioner to define the other terms in the Regulations. Even though the Commissioner, through his staff, labored long and earnestly to draft these definitions they have not been satisfactory to the mining industry, because the definitions in the Regulations and the interpretation placed thereon by the Commissioner do not state what the industry believes to be the clear and obvious intent of Congress. Consequently serious and prolonged disputes, unduly delaying the settlement of Federal tax returns involving percentage depletion deductions are continually arising between taxpayers and the Commissioner.

The only way to avoid these disputes is for Congress to amend the Code to state clearly the intended meaning of the terms upon which the computations depend. In the opinion of tax practitioners this can be done without lengthy additions to the Code. In their opinion if this is done it will simplify the computation of percentage depletion and greatly expedite the settlement of innumerable Federal tax returns involving percentage depletion deductions, the settlement of which are often delayed for long periods of time by lengthy and costly disputes over determination of the allowable deductions for percentage depletion.

The purpose of this paper is to discuss the Commissioner's interpretation of the terms upon which the computations depend with the intention of clarifying them for those concerned with figuring percentage depletion.

Preliminary to discussing the provisions under which percentage depletion is computed on mining properties for Federal income tax purposes, we should first consider the definition of depletion and second, the fundamental purpose of the allowance of depletion.

W. H. Wagner is a consulting mining engineer, a member of AIME and resides in Washington, D. C.

These are excerpts from an address before the Mining and Extractive Section of the Comptrollers Institute of American Convention in New York, Oct., 1948.

Because the Courts, in decisions involving depletion deductions under the Federal income tax laws, have consistently recognized mineral reserves as wasting assets, depletion may properly be defined as follows: **Depletion, as applied to mining, means the exhaustion or wasting away of a taxpayer's reserve of mineral in the ground due to the extraction and sale thereof.**

Speaking of the depletion deduction in one of the earlier decisions of the U. S. Supreme Court,[1] the Court said: "The deduction is to be regarded as a return of capital, not as a special bonus for enterprise and willingness to assume risks." This same principle has been stated in subsequent decisions of the court. Therefore it can be properly said: **The fundamental purpose of the allowance as depletion is to return to the owner, tax free, that part of his capital investment in the mineral reserve in the ground used up by production.**

The statutory right to percentage depletion is granted by Section 23(m) of the Internal Revenue Code (hereinafter referred to as the Code). This section provides merely for "a reasonable allowance for depletion" as a deduction from gross income and leaves to other sections of the Code the basis for computing the depletion allowance.

Section 23(n) immediately following refers to Section 114 of the Code for "the basis upon which depletion is to be allowed with respect to any property". Section 114 (b) 3 and 4 of the Code provide the basis for computing the percentage depletion allowances for oil and gas wells and for mining.

In order to give a clearer understanding of the percentage depletion allowances to mining and some of the difficulties encountered in computing the annual allowable deduction, it is important that we discuss some of the foregoing provisions of the Code.

Section 23(m) of the Code entitled "Depletion" provides:

"In the case of mines, oil and gas wells, other natural deposits . . ., a reasonable allowance for depletion . . .; such reasonable allowance in all cases to be made under rules and regulations to be prescribed by the Commissioner, with the approval of the Secretary. In any case in which it is ascertained as a result of operations or of development work that the recoverable units are greater or less than the prior estimate thereof, then such prior estimate (but not the basis for depletion) shall be revised and the allowance under this subsection for subsequent taxable years shall be based on the revised estimate. In the case of leases the deductions shall be equitably apportioned between the lessor and lessee. In the case of property held by one person for life with the remainder to another person, the deduction shall be computed as if the life tenant were the absolute owner of the property and shall be allowed to the life tenant. In the case of property held in trust the allowable deduction shall be apportioned between the income beneficiaries and the trustee in accordance with the pertinent provisions of the instrument creating the trust, or, in the absence of such provisions, on the basis of the trust income allocable to each."

"For percentage depletion allowable under this subsection, see section 114(b), 3 and 4."

Regulations by the Commissioner. As in all prior revenue acts, Section 23(m) of the Code in setting out the statutory right to a deduction as depletion provides only for a "reasonable allowance for depletion" and leaves the basis of computing such allowance to provisions in other sections of the Code. Likewise as in the prior revenue acts Section 23(m) provides, "such reasonable allowance is in all cases to be made under regulations to be prescribed by the Commissioner." Therefore, while the allowable percentage depletion deductions are statutory allowances at specified percentages of gross income from the property with stated limitations under section 114(b) 4 of the Code, the computations of the allowances must, unless otherwise expressed in the Code, be made under rules and regulations prescribed by the Commissioner of Internal Revenue. These rules and regulations are set out mainly in Section 29.23(m)—1 to (m)—16, Regulations 111.

Recoverable Units. In Section 23(m), as in most of the prior revenue acts, there is a sentence to the effect: where it is determined by operations or development work that the recoverable units are greater or less than the prior estimate, the prior estimate shall be revised and the allowance be based on the revised estimate.

As percentage depletion deductions are based on a percentage of gross income from the property, one may well think the number of recoverable units in a property upon which a percentage depletion deduction is claimed has no bearing upon the allowance. However, at the end of Section 114(b) 4 under which percentage depletion is computed for mines, provision is made that in no case shall the depletion allowance under Section 23(m) be less than it would be if computed without ref-

In determining the extent of an ore body, shown here at Allard Lake, you will arrive at the number of recoverable units contained therein, which will bear on your percentage-depletion deduction.

erence to percentage depletion. That is, where a property has a remaining undepleted cost or March 1, 1913 value basis at the beginning of the taxable year for which percentage depletion is being determined, both the cost or March 1, 1913 depletion and percentage—depletion deduction must be computed. The higher thereof is the allowable deduction for the taxable year.

The reason for reporting the revision in the number of recoverable units is that the Bureau insists in setting up the comparative table showing the higher amount of depletion deduction allowable annually, the remaining undepleted cost or March 1, 1913 value at the time percentage depletion became effective be amortized over the recoverable units on a basis that will show exhaustion when the mine is exhausted.

Taxpayer Entitled to Depletion. Section 23(m) provides in part:

"In the case of leases the deduction shall be equitably divided between the lessor and the lessee."

This provision was first enacted by Congress in the Revenue Act of 1918 and continued in the subsequent Acts and the Code. Prior to 1918 the Commissioner of Internal Revenue denied depletion deductions to lessees. However in Lynch vs. Alworth Stephens Co., [2] the U. S. Supreme Court held lessees were entitled to depletion deductions for the years prior to 1918.

In analyzing the foregoing identical provision in the Revenue Act of 1921 as the basis for the allowance of depletion deductions on a bonus and royalities received by a sub-lessor of oil and gas lands the Supreme Court in Palmer vs. Bender[3], said:

"The language of the statute is broad enough to provide, at least, for every case in which the taxpayer has acquired, by investment, any interest in the oil in place, and secures by any form of legal relationship, income derived from the extraction of the oil, to which he must look for a return of his capital."

Pursuing this matter further the Court concluded:

"A right to a depletion allowance does not depend on a retention of ownership or any other particular form of legal interest in the mineral content of the land. It is enough, if by virtue of the leasing transaction, he has retained a right to share in the oil produced. If so he has an economic interest in the oil in place, which is depleted by production."

Later in Bankline Oil Co.[4] the Supreme Court confirmed their decision in Palmer vs. Bender, supra, that the right to a depletion allowance depended on the acquistion or retention of an "economic interest" in the mineral content of the land. However, the Court stated:

"But the phrase 'economic interest' is not to be taken as embracing a mere economic advantage derived from production, through a contractural relation to the owner, by one who has no capital investment in the mineral deposit."

Following these and other like decisions the Commissioner of Internal Revenue incorporated the foregoing words of the Court, with amplifications, in Sec. 29.23(m) —1, Regulations 111.

Thus under the provisions of the Code as construed by the foregoing and other Court decisions and under the provisions of the Regulations, operating owners' lessees, sublessors, sublessees, life tenants (but not remaindermen), purchasers of royalty interests, owners of fractional and overriding royalty interests, tenants in common, trusts and beneficiaries (depending on how the income is distributed) of mineral lands have an "economic interest" in the mineral in the ground entitling them to their respective share of the depletion deduction on the income received therefrom. This is true because they have either an investment in, or have secured by a legal relationship, an interest in the mineral which forces them to look to the income from the extraction of the mineral for return of their capital.

The foregoing statement covers the status of the great majority of cases wherein the right to the deduction as depletion is reasonably clear. There remains a group of cases wherein the right to the deduction is not so clear or where such right is questioned by the Commissioner. To the mining industry the most important of these latter cases involve situations where the taxpayers claiming percentage-depletion deductions entered into contracts with the owner of mineral deposits to mine the mineral from the deposits at stated rates per ton. In the two such cases adjudicated by the courts to date, the courts reversed the Commissioner and allowed the taxpayers percentage-depletion deductions on all the mineral mined. It is my understanding many other such contract cases, involving varying types of contracts, are presently being studied by the Commissioner's legal staff for the purposes of determining a policy in the light of the two above decisions and a ruling may be handed down in the near future.

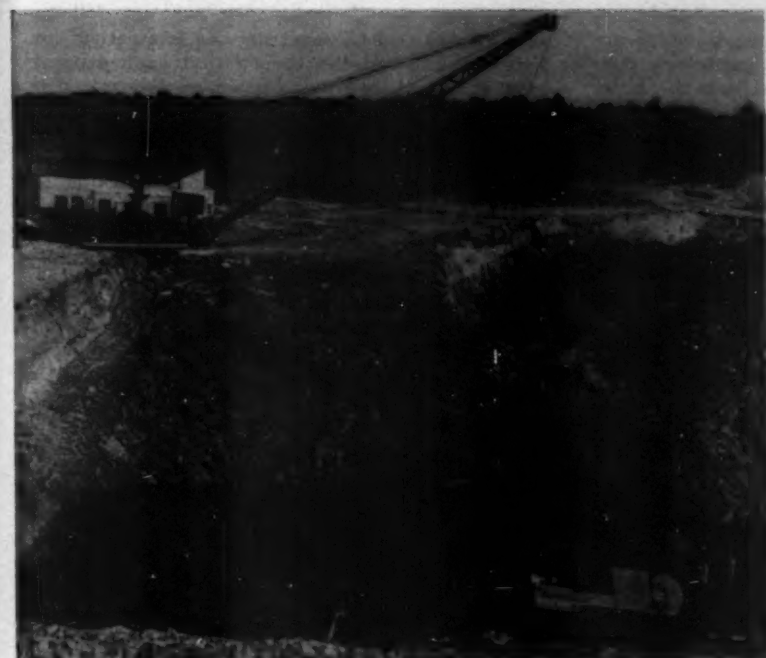
As previously stated the basis upon which percentage depletion is allowed is contained in Sections 114 (b) 3 and 4 of the Code. Section 114 (b) 3, first enacted by Congress in the Revenue Act of 1926 and now a part of the Code, provides that the allowance for percentage depletion in the case of oil and gas wells under Section 23 (m) shall be 27½ per centum of the gross income from the property during the taxable year, etc.

Section 114 (b) 4, first enacted by Congress in the Revenue Act of 1932 and now in the Code with certain additions, provides for the allowance of percentage-depletion deductions for coal and metal mines, for various other mineral mines and deposits at varying percentages of the gross income from the property.

The provisions of both the above sections of the Code as to the property involved, net income limitations, etc., are identical, except as to the percentage of the gross income allowable as a deduction as percentage depletion for the several stated natural resources. As the interpretation of the provisions of one section will in general apply to the other section, and as this discussion deals mainly with mining, I will in the interest of space quote and discuss only Section 114(b) 4 applying to mining.

This section provides in part as follows:

"The allowance for depletion under section 23(m) shall be, in the case of coal mines, 5 per centum, in the



As this coal stripping operation progresses, new parcels of land may be added and these reserves must be added to the previously determined estimate of recoverable units.

case of metal mines, bauxite, fluorspar (and numerous specified minerals and deposits), and potash mines and deposits, 15 per centum, and in the case of sulphur mines or deposits, 23 per centum of the gross income from the property during the taxable year, excluding from such gross income an amount equal to any rents or royalties paid or incurred by the taxpayer in respect to the property. Such allowance shall not exceed 50 per centum of the net income of the taxpayer (computed without allowance for depletion) from the property, except in no case shall the depletion allowance under section 23(m) be less than it would be if computed without reference to this paragraph."

At first reading the provisions of this section sound very simple of application. The allowable deduction for percentage depletion appears to be a stated percentage (depending on the mineral involved) of the "gross income from the property" during the taxable year limited by 50 per centum of "the net income from the property." However, none of the terms, except "gross income from the property" in the case of mines, upon which the computations depend, are defined in the Code. The other terms are defined in the rules and regulations prescribed by the Commissioner under the authority of Section 23 (m).

Gross Income from the Property. In the case of mining the "Definition of Gross Income from Property" appears as sub-section 114(b) 4 B of the Code. This definition was added to the Code, retroactive to 1932, by Congress as an amendment in the Revenue Act of 1943. Prior to that time the definition was in the Regulations only.

The definition in the Code provides that "the term gross income from the property means the gross income from mining" and "the term mining shall be considered to include not merely the extraction of the ores or minerals from the ground but also the ordinary treatment processes normally applied by mine owners or operators to obtain the commercially marketable product or products." The ordinary treatment processes to be thus included in mining are specifically named in the definition as to each mineral entitled to the percentage depletion allowance. Under the definition the sale value of "the commercially marketable product or products" at the end of the named treatment processes is to be taken as the gross income base for the purpose of computing the allowable deduction.

From the legislative history and background of the foregoing amendment it is clear Congress intended to express their original intent at the time percentage depletion was granted to mining in the Revenue Act of 1932, and to so state that intent as to achieve administrative certainty and thereby eliminate the administrative controversies that had been constantly occurring in the determination of gross income from the property under the definition in the Regulations prior to 1943. To achieve such administrative certainty it is necessary to give the amendment a common-sense interpretation. To accomplish this it is necessary, except for the presence of extraordinary or abnormal facts which unreasonably distort the final answer, to treat all the incidental and necessary costs prior to completion of the stated ordinary treatment costs as a part of mining in determining the gross income base.

With one exception the Commissioner's administrative interpretations since the amendment was adopted have appeared to follow such a common-sense interpretation. This exception has developed where the mine operator has, due to physical con-

ditions of the terrain, the lack of water at the mine, etc., been compelled to build his mill, in which are installed the ordinary treatment processes enumerated, at a considerable distance from the mine. Such an operator is compelled to transport the ores or minerals a greater distance from the mine to the mill, than is normally the case, in order to secure the commercially marketable mineral product specified in the amendment.

In the application of the amendment the Commissioner has taken the position that such transportation to the mill is to be treated as part of mining only where the mill is in close proximity to the mine, and the cost of any transportation beyond that distance must be deducted from the gross income base. This question is still unsettled. Consequently it cannot be stated what distance is meant by the term close proximity. It is understood to be not over one to two miles. It appears impractical to establish the limitation in terms of miles, because of the varying conditions of terrain, water supply, etc., as between the different mining areas. If any limitation must be made it appears that in the interests of justice such limitation should be on the basis of engineering considerations as to the location of the mill from the standpoint of economic and efficient operation. This will avoid any abuses in applying the provisions of the amendment.

Definition of the Property. The determination of what constitutes "the property" has been the basis of many and continuing disputes between taxpayers and the Commissioner.

Under the statute the allowance for percentage depletion is a stated percentage of the gross income from "the property." The term "the property" is not defined in the Code. Sec. 29.23 (m) —1 (i), Regulation 111 defines it as follows:

"The property as used in section 114 (b) 2, 3 and 4 and sections 29.23 (m) - 1 to 29.23 (m) - 19, inclusive, means the interest owned by the taxpayer in any mineral property. The taxpayer's interest in each separate mineral property is a separate 'property'; but where two or more mineral properties are included in a single tract or parcel of land, the taxpayer's interest in such mineral property may be considered to be a single 'property', provided such treatment is consistently followed."

Such definition has been in the regulations in substantially the same form since percentage depletion was granted to mines in the Revenue Act of 1932.

Sec. 29.23 (m) —1(b), Regulations 111, defines a "mineral property" to mean "the mineral deposit, the development and plant necessary for its extraction, and so much of the surface of the land only as is necessary for purposes of mineral extraction." Therefore the common sense and practical interpretation of the term "the property" in Sec. 29.23 (m) —1(i) appears to denote "the property" as meaning the tract or tracts of land, regardless of their possible different dates of acquisition, enclosing the mineral deposit being extracted through one extraction plant. If that theory is followed, there will be a minimum of difficulty in determining what part of the taxpayer's holding shall be considered in computing the gross income base.

However, the Commissioner has not followed such theory. On the contrary, he has rather consistently followed the theory that each separate interest owned by the taxpayer, as determined by acquisition and conveyance, is a "single property" for the purpose of computing depletion. The theory in so holding is that "the property" is the same for depletion (including percentage depletion) as for determining gain or loss. Consequently the determination of the question has led to many disputes. It is still in dispute.

The question was first taken to the courts by the Vinton Petroleum Co.[5] This was an oil and gas case under the Revenue Act of 1926. This case arose before mines were granted percentage-depletion deduction allowances. In that case the court held:

Where oil is being produced from wells on eight different but neighboring tracts acquired at different times, some in fee simple and some under leases . . . "Deduction for depletion by taxpayer must be estimated separately on gross income from each tract and not on aggregate from all."

Subsequently the Commissioner issued a ruling[6] defining "the property" as follows:

"The term 'property' as used in the provisions of the Revenue Act of 1934 and the corresponding provisions of subsequent Revenue Acts and of the Internal Revenue Code providing for the allowance of depletion and fixing a basis for the computation of such allowance means each separate interest owned by the taxpayer in each separate tract or parcel of land, whether separated geographically or by conveyance. If a taxpayer holds several different interests in the same tract, each interest is a separate property."

Applying this principle to a taxpayer operating a mine made up of a consolidation of several parcels of land the fees or leases to which were acquired at different times or under separate agreements and conveyances means he will be compelled to compute separately his annual depletion allowance on each separate tract. This will be true even though the mine is operated as a unit through one shaft or mine opening and under one operating staff. Such procedure results in an undue amount of record keeping and may well result in an unfavorable depletion allowance to the taxpayer as compared to computing allowance on the basis of the operating unit being "the property."

Three years later the Commissioner issued a ruling[7] restating the fundamental principle of the previous ruling([6]) and holding that "Aside from the combination of separate economic interests in separate mineral deposits on the same tract or parcel of land, no combination of economic interests is permissible."

Since then there have been several court decisions contrary to the Commissioner's procedure. In The Black Mountain Coal Corp. Case[8] the Court upheld the taxpayer's contention:

"That 'the property' as used in Section 114 (b) 4 means the economic and practical unit which the taxpayer must use and develop in order to extract a particular block of coal. It includes whatever portion of the mineral deposit can be properly mined as a unit and it includes also the development, plant, and surface land necessary for the extraction of that particular block of coal. Under this theory a large block of coal acquired at one time might constitute more than

one property, or smaller blocks of coal acquired at different times might be combined to form a single property."

In Amherst Coal Co. Case[9] where the taxpayer carried on its coal mining operations through three mines over two tipples on a property made up of several parcels acquired at different times, some as fee owner and some as lessee, maintained only one cleaning plant, one maintenance crew and shifted employees and equipment from one mine to another as required and prorated management and similar expenses on the basis of production, but maintained separate accounts as were necessary to compute royalties due on the various leases and show the costs and profits on each mine, the Court held the taxpayer could treat the three mines as a "single property" for the purposes of depletion. In so holding the court said the taxpayer met the prescribed test of the Regulations to be so treated as laid down in the Jewel Mining Co. decision[10] to wit:

(1) The income from all properties must be consistently treated by the taxpayer as arising from a single property in computing the depletion allowance.

(2) There must be an interest owned by the taxpayer in each property, that is, in the mineral deposit, the plant for its extraction and the necessary surface land.

(3) The properties must be included in a single tract or parcel of land.

There have been other like decisions against the Commissioner's procedure and in favor of the theory that "the property" is in fact the single unit of operation. Yet the Commissioner appears to be standing by his enunciated principle that "each separate acquisition is a separate property" for the purpose of computing percentage depletion.

Net Income from the Property. It has been noted that while Section 114 (b) 4 states the allowance for percentage depletion shall be a specified per centum of the gross income from the property, "such allowance shall not exceed 50 per centum of the net income of the taxpayer (computed without allowance from depletion) from the property . . . ." The provisions of the statute relating to percentage depletion as first enacted years ago and since re-enacted have not stated what is meant by net income from the property. The definition thereof was written in the Regulations following enactment of the percentage depletion provisions into the Code. Said wording has been continued substantially without change in all subsequent regulations. It is currently stated in Sec. 29.23 (m)—1(g), Regulations 111 as follows:

"Net income from the property, as used in Sections 114 (b) 2, 3 and 4 . . ., means 'the gross income from the property . . .' less the allowable deductions attributable to the mineral property upon which the depletion is claimed and the allowable deductions of the processes insofar as they relate to the product from the property, including overhead and operating expenses, development costs properly charged to expense, depreciation, taxes, losses sustained, etc., but excluding all allowance for depletion. Deductions not directly attributable to the particular properties or processes shall be fairly allocated. . . ."

In practice the Commissioner interprets this definition to mean that in determining net income from the property the gross income from the property must be reduced by the sum of the following expenses; all costs of producing the mineral upon which the depletion is claimed, all costs of the enumerated processes to the point where the gross income is determined, overhead (including interest on bonded and other indebtedness), depreciation, taxes (including state income taxes and capital stock taxes), losses sustained, and other charges not directly related to the mineral upon which the depletion is claimed. Where more than one property is in operation or activities other than mining are engaged in by the taxpayer the Commissioner allocates the overhead, etc., under provisions of the Regulation not quoted above.

The courts have generally supported these administrative determinations where the law is not definite in describing its basis. For example, in Sheridan-Wyoming Coal Co.[11] the Court held;

Where the taxpayer elected to have allowance for depletion of coal mines computed on percentage depletion basis under the statutory formula allowing 5 percent on gross income during the taxable year, such allowance not to exceed 50 percent of the net income from property, the Commissioner properly excluded from the net income the profit realized from the purchase of its own bonds because the transaction of buying up its own bonds was outside taxpayer's business of mining coal and at the same time properly included interest payments on outstanding bonds, bond discount, and expense of amortization of bonds with the other expenses in arriving at the net income.

Again in Montreal Mining Co.[12] the tax Court held;

In computing taxpayer's net income for percentage depletion for the taxable year 1935, under the Sec. 114 (b) 4, Rev. Act of 1934, amounts paid in 1935 for the settlement of silicosis claims must be deducted for its gross income, even though the claims thus paid arose in prior years and had no direct relation to the mineral produced in 1935 upon which depletion was claimed.

To the contrary, taxpayers in the mineral industry have consistently contended the Congressional intent of the limitation is that the percent-

If your concentrating plant does not prepare ore for extraction of metal, you are not entitled to a metal-ore depletion deduction.

age depletion allowable shall not exceed 50 per cent of the net income from the property from which the mineral is produced regardless of (1) the form of its ownership and (2) the manner in which the operation was financed. That is, deduction should be made only for expenses directly connected with the production of income from the property and for such portion of the indirect and overhead expenses as definitely contributed to the income from such property. To meet this standard the deduction should not be increased by expenses applicable to other properties, by interest paid on indebtedness, by taxes based on or measured by income, by capital stock taxes, and by other charges which are not direct costs of producing income from the property against which the depletion deduction is claimed.

If the deductions are increased by these latter expenses gross inequalities are set up between producers in like industries in determining their depletion allowances. For example the deduction of interest on indebtedness penalizes a company which raised its capital through bonds or other borrowing as against a company which raised its capital through the sale of stock. Likewise if the deductions are increased by state income taxes an operator in a state assessing such taxes is penalized as compared to an operator in a state not having such a levy. Other deductions set up like inequalities between operators. It is unreasonable to assume Congress intended by the very wording of the statute to create such economic inequalities in determination of the depletion allowance.

Definition of a Metal Mine. Sec. 114 (b) 4 as first enacted in the Revenue Act of 1932 and reenacted in all the subsequent Revenue Acts and the Internal Revenue Code states:

> **"The allowance for depletion under section 23 (m) shall be, . . ., in the case of metal mines, . . . 15 per centum, of the gross income from the property during the taxable year, . . ."**

The term "metal mines" was not defined in the Revenue Act of 1932, in none of the subsequent Acts, or the Code. The Commissioner made no attempt to define the term in the Regulations following the Revenue Act of 1932, the subsequent revenue acts, the original Code in 1939, and the re-enactments thereof until 1944. Apparently this was not done, because the specific meaning of the term was understood by Congress, the Commissioner, and industry to apply to operations engaged in producting minerals scientifically classified in the mineral industry as being a metallic substance as compared to a nonmetallic substance in mineral classifications.

However, in 1944, the Commissioner issued a ruling[13] as an amendment to Sec. 29.23 (m)—5 of the Regulations 111 which in substance stated as follows:

> **"Where a mine produces an ore containing substances which are susceptible to both metallic and nonmetallic uses, or where a mine produces both metallic and nonmetallic substances from the same ore body, percentage depletion may be computed for Federal income tax purposes on the part sold or used as a metal or metals, and that part sold or used as a nonmetal should be treated as a nonmetal in determining the nature and extent of the depletion allowance."**

Since issuance this ruling has become known as the "end use" theory. In substance it means, where percentage depletion is claimed on a metal mine entitled to such allowance under Sec. 114 (b) 4 of the Code, if it can be shown any part thereof was sold or used for so-called nonmetallic purposes, that part so sold or used loses its metallic classification and will be denied a deduction as percentage depletion. For example lead and other metals entitled to the deduction under the statute if sold or used in manufacture of paint will lose the deduction. There does not appear to be anything in the prior Revenue Acts, the Code, or the Congressional Committee reports back of them to show Congress intended any such limitation.

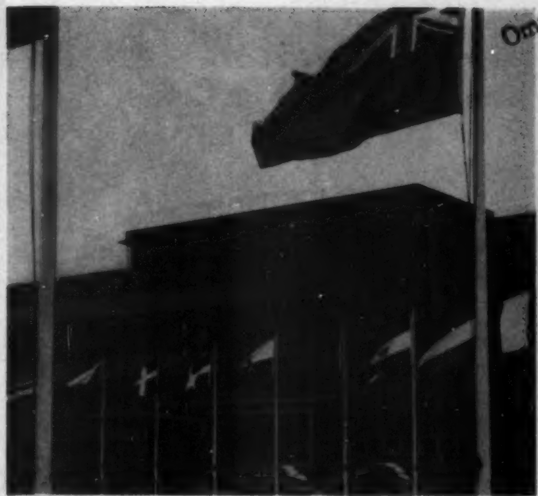
So far as I know this question has to date been brought up for judicial determination in only one case, to wit, E. J. Lavino & Co.[14] From the record in that case it appears the taxpayer was the operator of chromite properties in Cuba and it used the ore extracted therefrom solely for the purpose of manufacturing refractory furnace linings which did not involve the reduction of the contained chromium mineral to a metallic form. On the basis of these facts the Court denied the taxpayer the deductions claimed as percentage depletion on the ground that while the metal chromium might have been extracted from the ore from its mines, it was not necessary to do so when the ore was used for refractory purposes. Therefore the mines did not come within the classification of metal mines entitling them to percentage-depletion deductions in the years in which the deductions were claimed.

I have often been asked for my opinion as to the weight of this decision. I can only say the case is not representative of the usual mining situation and in my opinion is not determinative of the issue as it usually arises.

There are other situations arising in the application of the Federal taxing statutes to mining wherein percentage depletion is directly or indirectly involved. These are the questions of development charges, capital versus expense charges, the computations of the net operating loss carry-back and carry-forward, etc. They all give rise to difficulties and inequities in settling mining tax returns, which could also be eliminated or minimized by legislative amendments to the Code.

References

[1] U. S. vs. Ludey 274 U. S. 295.
[2] 267 U. S. 660.
[3] 287 U. S. 551.
[4] 303 U. S. 361.
[5] 71 Fed. (2d) 420.
[6] G. C. M. 22106, C. B. 1941—1, p. 245.
[7] G. C. M. 24094, C. B. 1944, p. 250.
[8] 5 T. C. 1117 (11-23-45).
[9] 11 T. C. No. 32 (8-30-48).
[10] 126 Fed. (2d) 1011.
[11] 125 Fed. (2d) 42.
[12] 41 B. T. A. 399.
[13] G. C. M. 24185, C. B. 1944, p. 132.
[14] 72 Fed. Sup. 248.



United Nations Headquarters, Lake Success, N. Y.

United Nations World Resource Conference

Lake Success, Aug. 17—Delegates to the United Nations Scientific Conference on the Conservation and Utilization of Resources convened today for the opening session in an atmosphere of international co-operation. A glance at the roster shows that there are few countries outside the iron curtain which are not represented.

Although not a policy-making group, the conference is organized under the auspices of the Economic and Social Council of UN for the purpose of exchanging information on the application of science to resource management and human use. The development of technique and administration in this field is the work of many experts of many kinds throughout the world. No country has a monopoly of the best methods; every part of the world has contributions to make and significant experience from which those responsible for resource use have much to learn.

The environment of the conference is singularly befitting its high-minded purposes. The corridors leading to the meeting hall are of spacious futuristic design. Once inside the meeting room and equipped with a portable radio language translator, ones attention is focused on the long crescent-shaped table at the front of the room behind which the speakers are seated. Each has a microphone before him. The speaker's voice is audible in every part of the room and seated beneath fluorescent lights filtered through a grid in this soundproofed room with translators, news-reel cameras, and radio announcers in their glassed-in cubicles set in the walls one cannot help but feel awed.

On this first day of the conference there are many notables present in the fields of water power, forests, wildlife and fisheries, agriculture, and fuels and minerals. AIME members in view are L. E. Young, John R. Suman, James L. Head, Julian W. Feiss, James A. Barr, Alan F. Mathews, G. C. Gester, Lester C. Uren, and Theron Wasson.

Chairman S. S. Bhatnagar, secretary to the Government of India, Department of Scientific Research, opened the first session on conservation by introducing Fairfield Osborn, president of the Conservation Foundation. Mr. Osborn anticipates a more serious problem in shortages of our replaceable resources, forest, arrable land, etc., rather than from minerals and fuels. This situation, he explains will be aggravated by our increasing world population. Human ingenuity will find substitutes for our inorganic resources and fuels whereas it cannot create life. The failures of the past in conservation have not been so much those of lack of knowledge as of lack of its sustained application. Mr. Osborn closed by saying that conservation efforts must be based on world co-operation.

The other speaker on the program was Colin Clark, permanent under-secretary for labor and industry, Queensland Government, Australia. Mr. Clark said that while man has proved himself capable of the most appalling misuse of natural resources under certain circumstances, he has also shown himself capable of scientific improvement of agricultural technique capable of raising the product per man-year at the rate of 1½ percent per annum. Even in some of the crowded areas of Europe and Asia great increases in agricultural production have been achieved. The world's population is increasing at the rate of 1 percent per annum and our problem is clearly soluble if we go about it the right way. The world shortage of food is not due to lack of land, but to lack of labor. In almost every country industrialization is taking labor away from agriculture. (The shortage is needlessly accentuated by the action of countries like Australia and Argentina in accelerating industrial development when their agricultural resources are still largely unused.) World food prices will have to rise about 70 percent relative to industrial prices, he said, in order to attract sufficient labor back to agriculture to meet the world's demands for an increasing standard of living. Even under favorable circumstances this process will take 20 or 30 years.

Mr. Clark felt that the world rate of population growth has accelerated since 1920 as a consequence of declining mortality, not of increasing reproduc-

tivity. Reproductivity is now falling rapidly in Japan, Russia, India and all countries which have established contact with "western civilization"; while in China, mortality is so high that population appears to be stationary or declining in spite of high reproductivity. The claim that in countries where fertility is high it should be artificially reduced is thus groundless economically; its real origin appears to lie in a feeling of race superiority on the part of Europeans and North Americans which the rest of the world bitterly resents.

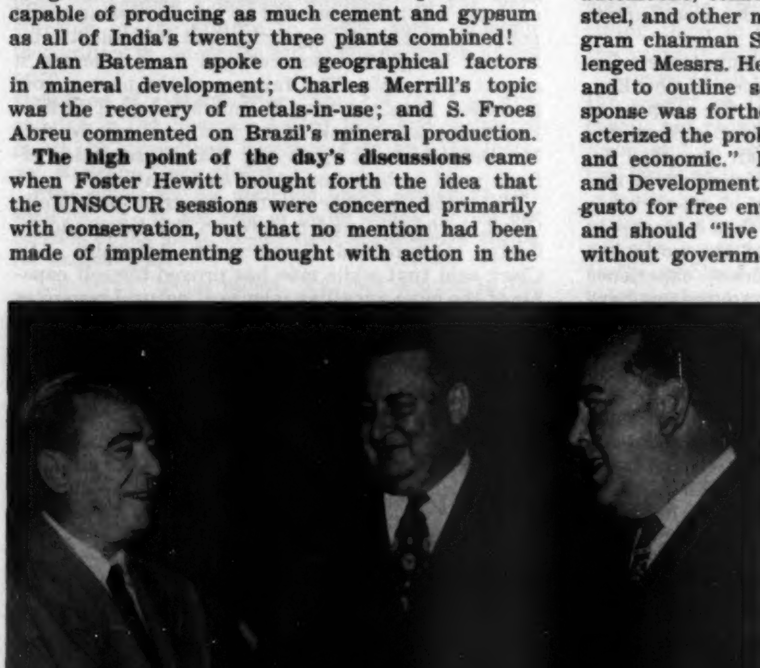
August 23—Elmer Pehrson led off the Minerals Section meeting with a discussion of world mineral reserves, complete with numerous tables showing their present status. At present production rates, he said, our coal should last for 2200 years —but the figures show that if all the world consumed at the present per capita rate of the U. S. A., the world's coal reserves would be depleted at the end of only 340 years. Great Britain's W. F. P. McLintock suggested, however, that Mr. Pehrson's estimates were "too pessimistic" and called upon him to "be of good cheer" since new ore bodies are always being opened in hitherto unsuspected localities. India's Mr. Rajagopalaswami was a lone voice in the wilderness of world wealth with his recounting of the problems encountered in Indian cement and gypsum production. He told the gathering that three of America's western plants were capable of producing as much cement and gypsum as all of India's twenty three plants combined!

Alan Bateman spoke on geographical factors in mineral development; Charles Merrill's topic was the recovery of metals-in-use; and S. Froes Abreu commented on Brazil's mineral production.

The high point of the day's discussions came when Foster Hewitt brought forth the idea that the UNSCCUR sessions were concerned primarily with conservation, but that no mention had been made of implementing thought with action in the

Delegates registering for the UNSCCUR meeting.

form of controls. Julian Feiss of the Bureau of Mines opined that vanity was at the source of excessive mineral consumption, and that the sight of one human moving along a highway in a 120-hp automobile, consuming gas, oil, rubber, chromium, steel, and other minerals was a ludicrous one. Program chairman S. Raushenbush immediately challenged Messrs. Hewitt and Feiss to be more specific, and to outline some program of action. No response was forthcoming, but Mr. Feiss later characterized the problem as "sociological, edueational, and economic." Paul Foote of the Gulf Research and Development Corp. then carried the ball with gusto for free enterprise, and claimed that we can and should "live extravagantly" if we so desire, without government interference.



New York's Mayor William O'Dwyer greeting U. N. Secretary-General Trygvie Lie (right) and Julius Krug, Secretary of the Interior, as the Conference opened on Aug. 17.

aime NEWS

Directors, at Special July Meeting, Amend Bylaws and Appoint Lippert Publication Manager

Ordinarily the Board of Directors of the Institute does not meet in July and August but several matters of importance made such a meeting necessary this year. President Young presided, with eleven other members of the Board present: Messrs. Daveler, Elkins, Head, Kinzel, Kraft, Meyerhoff, Peirce, Phillips, Price, Schumacher, and Fletcher. The date was Aug. 17.

Revisions in the bylaws, as printed in the June issues of the journals, were approved without further discussion. These increase the dues by $5 for Members and Associate Members, and by $2 for Junior Members, for the years 1950, 1951, and 1952, at which time another referendum will be taken as to the scale for the future. Also, the grade of Junior Foreign Affiliate is discontinued at the end of the current year, and the time in which a Student Associate may remain such is now limited to the end of the year in which he is in university residence as a student, instead of the end of the following year as before.

Appointment of Thomas W. Lippert as Manager of Publications on a two-year contract was confirmed by the Board, and he was introduced to those present. Comment on this appointment appears in "The Drift of Things."

Considerable discussion developed, inspired by a letter from Charles T. Holland, on whether or not a change should be made in the scale of Student Associate dues. At present, Student Associate affiliation, including a year's subscription to one of the three journals, is $4.50, but an alternative of $2 is offered without an individual subscription to a journal, in which case copies are supplied to the Affiliated Student Society for reference on request. A proposal had been made to eliminate the $2 fee, and possibly to reduce the $4.50 fee to $4. About one quarter of the Student Associates currently pay $2 and three quarters $4.50. The views of several members of the Mineral Industry Education Division were reported, and the student dues schedules and privileges of the other Founder Societies compared with those of the AIME. Lengthy discussion of the matter at the El Paso meeting in 1948 was reviewed. It was finally unanimously decided to retain the present bylaw as to student dues.

Another matter for discussion was the terms under which AIME members should receive the annual volume, "Statistics of Oil and Gas Development and Production," for 1950. The last two volumes have cost from $10,000 to $12,000, which is offset only to the extent of $5000 by receipts from the Doherty Memorial Fund. Several years back the material therein contained had been supplied to Petroleum Division members bound in with the regular petroleum volume each year and the extra cost of binding it separately was supposed to be met by the Doherty Fund contribution. Mr. Elkins explained the matter to the rest of the Board, which then voted to make the 1950 volume available free on request to all Members, Associate Members, and Junior Members who take the **Journal of Petroleum Technology,** but to charge Student Associates $3 should any of them wish to have the volume, and to charge others $6.

Reports were made of a continuing investigation into possible economies in printing, and Mr. Lippert promised further data at the Sept. 27 Board meeting in Columbus.

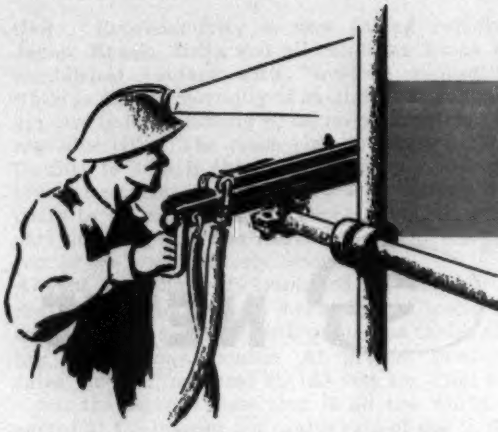
A new Student Chapter was recognized at Fenn College, Cleveland.

H. G. Moulton was named as AIME representative on the Engineers Joint Council Committee on Engineering Personnel in the Military Establishment. The date of the November Board meeting was set at 2 p. m., Wednesday, Nov. 16.

Mr. Peirce made a short progress report of the work of his committee on Instructions to the Nominating Committee, and was directed to expand the work of his committee to include a study of the basic features of the present system of member representation through Directorships.

Currently new members do not receive copies of the journals until they have accepted election, but it was voted to return to the old system of putting applicants on the subscription list for the journal of their choice as soon as their applications are received.

Special messages of congratulation were voted to Herbert Hoover on the occasion of his 75th birthday anniversary on Aug. 10, and to D. C. Jackling, on his 80th birthday on Aug. 14.



THE DRIFT OF THINGS

. . . as followed by EDWARD H. ROBIE

A Manager of Publications

Among the major recommendations of the Johnson Committee, as reported to the Board at the Annual Meeting last year, was "that the services of an editor and publisher of broad practical experience in this highly technical field should be procured as soon as circumstances permit." This and some other recommendations and suggestions of the Committee have not been forgotten and another step in carrying them out was made in July when T. W. Lippert was engaged as Manager of Publications.

Although the desirability of engaging a man thoroughly conversant with editorial, advertising, and circulation problems in the AIME's field had been recognized, the possibility of securing a qualified man, and especially at a price the Institute could afford to pay, had not been thought too bright. But on June 21 a short news item in the New York newspapers told of a major reorganization of the staff of **The Iron Age**, which had been followed by the resignation of the directing editor, Tom Lippert.

The possibilities for the Institute in this news item were apparent. Tom Lippert had established quite a reputation on **The Iron Age**, not only as an editor but in assisting the "publisher," and the magazine itself has become perhaps the most successful publication in the mineral industries field. Furthermore, Tom had been a member of AIME for fourteen years, joining two years after receiving his M.S. at Carnegie Tech in 1932, so was familiar with Institute affairs. Within a week after the news broke, a tentative agreement had been made between the Secretary and Mr. Lippert for a two-year contract, by the end of which time it was felt that his ability at improving the Institute's journals and increasing their net income could be proved. The whole story was mailed to the 36 Directors of the Institute on July 1, after several had been personally approached or had given their tacit approval by telephone. Twenty-nine of the 36 replied, unanimously approving the proposal, and Lippert's engagement was formally ratified by the Board at its July 27th meeting. Quick action had been necessary because other opportunities awaited him.

Tom's experience has been principally in the field of **The Journal of Metals**, so his immediate duties will be chiefly concerned with the editorial and advertising departments of that journal, to which a major proportion of his salary and expenses will be charged. He will, however, also supervise the editorial and advertising activities of **Mining Engineering.** For the time being, at least, these two journals will take up all of his time, but if and when the Petroleum Branch wishes to avail itself of his services it is hoped that he can extend his interests to that publication. He is also nominally for the present in charge of all Institute book publishing.

Although this step means an immediate increase in AIME expenses, it is confidently expected by all concerned that by a year from now a net gain will result, and that editorially the journals will be even more attractive than at present. It might also be mentioned that the combined salaries of the new Manager of Publications and the Secretary are less than were the combined salaries of the former Secretary and of the Assistant Secretary (who has now become Secretary) so no increase has thus been made in Institute salary expenditures in the "top brass" category.

Naming Committeemen

In naming chairmen of committees, and to some extent in nominating men for Directorships in the Institute as well, one is faced with two alternatives: (1) to name a man for another term, if he has done an exceptionally good job; or (2) to pick an entirely new man. The advantages and disadvantages of each principle are obvious. We are inclined to favor the second alternative, but with this general qualification—that the man selected shall already have served a term as vice-chairman, or at least as a member of the committee, so that he can be reasonably familiar with what he is supposed to do. Certainly we think there is nothing more likely to make for dry rot, nor to annoy those who are interested in a committee's work but never receive recognition, than to retain the same committee chairman and personnel every year, with only an occasional introduction of new blood, perhaps when somebody dies.

One of course likes to retain the services of a man who has done a job with conspicuous success; it perhaps may be regarded as an honor to him, and of benefit to the Institute, to ask him to serve again, but on the other hand, he is probably a busy man who has a salary to earn, and a good and willing horse should not be overworked.

As to the plain committeemen, those who never find their names on a committee sometimes complain that they go entirely unrecognized, and that the group seems to be a little clique of insiders. It has been

our experience, however, that this is not so, but rather that the practice of continuing names on a committee results from the not unnatural human tendency to do a job the easiest way. Many willing and capable men are entirely unknown to the person who picks a committee. Here is where modesty is a fault. If you wish to work on a committee, and feel that you can contribute something to its work, it devolves upon you to let yourself be known. The Executive Committee or the Chairman of your Division will be only too glad to know of your willingness to do committee work. So will the Secretary of the Institute. Don't wait for a formal invitation, or remain aloof in the hope that your name will some time be drawn out of the hat—your name probably isn't in the hat at all.

You haven't time for committee work, anyway, you say? Nonsense. That means you haven't time to work with the men engaged in an activity similar to yours, to find out what they are doing, and what others in your field are doing, to make personal friends who may in a five-minute telephone conversation tell you what it would take you five days of research to find out all by yourself.

If you are not satisfied with what you are getting out of the Institute, the solution of your difficulty may well be connected with the answer to a question that you can ask yourself: What am I contributing to the Institute? If you reply that you pay your dues regularly, that is an inadequate answer.

Two Unions Sign Up

Faced with the fact that efforts to repeal the Taft-Hartley Act have been unsuccessful in the present session of Congress, the International Union of Mine, Mill, and Smelter Workers and the United Steel Workers have decided to sign the non-Communist affidavits required under the Act in order to secure recognition as bargaining agents by the National Labor Relations Board. As to the Steel Workers, this may presage action through the NLRB in the current wage-pension dispute with the steel industry, which is enjoying a two-months' truce expiring Sept. 15. As to the IUMMSW, the action seemed necessary in order to protect itself against the competition of rival unions in the CIO. Heretofore it has not had the right to have its name appear on NLRB ballots. Not only has it been disliked by employers who have had to deal with it, but has also been torn with internal dissension. It is well known, or at least it is currently believed, that the IUMMSW is directed to a considerable extent by Communists and fellow travelers, and whether or not any change in its officers is planned or not remains to be seen. In any case the NLRB and the Department of Justice might well cooperate in a close study of the non-Communist affidavits.

Free College Educations

Another step in making it easy to get a professional education is reported from Argentina where tuition will no longer be charged by the National University of Buenos Aires. All citizens who can pass the entrance examinations have a chance for six years' study at state expense. They can become doctors, architects, engineers, or select any other profession. Six years of study will be provided in the schools and colleges under the supervision of the University, the cost of which heretofore has been about $2400.

In the United States the nearest similar type of education is that which has been provided by the Government under Public Law 346, the so-called G. I. Bill. Last year close to a million veterans were in schools under the terms of this act, which gives up to four years' training, depending on the duration of their active military service. As much as $500 a year is allowed for tuition fees, books, and supplies; and from $75 to 120 a month for subsistence.

State universities provide an education at nominal tuition fees to state residents, and several city universities and colleges give free or nominal tuition to city residents, but we have no Federal university.

Here in New York State a movement is on foot to set up a state university, and we have been approached as to whether or not a mining course should be included. For years there has been something at Albany called the University of the State of New York but it exists in name only so far as the popular understanding of the term goes. Our reply to the questionnaire we fear was not too encouraging; we do not feel that a new school in New York State to teach any branch of mineral technology is needed.

Private Enterprise

Doubtless it's an old yarn, for it came to us via New Zealand and Canada, and our eyes and ears have not been attuned much in the last year to the lighter side of life, but for the benefit of those to whom it is new, we offer the following ancedote in somewhat abbreviated form:

A foreign reporter was trying to find out how the working class in America felt about our capitalistic practices, and among others interviewed a typical factory workman.

"What do you think about the way the workman fares under the American system?" he asked. "Why, I think it's wonderful." "You do? Why?" "Well, in so many ways. Just an example: You finish a hard day's work and are waiting at a near-by corner for a bus to take you home. Along comes the boss, riding alone in a big car, and he stops and asks if he can give you a lift. He asks where you live and you tell him you live in the city about ten miles away. He says he will be glad to drive you there, that he wants to get your point of view and talk over your work, but must stop at his house first and make an important telephone call. You tell him you'll be glad to wait, and while he is making his call he invites you in for a drink. After that is finished he says dinner is ready so you might as well stay and he will drive you home afterward. After dinner you're sitting around the living room chatting with the boss, when he says, "It's getting pretty late so you might as well stay right here and I'll drive you to work in the morning." This seems like a sensible suggestion, so you agree.

By this time the reporter's eyebrows were raised in amazement at this evidence of American democracy. "Do you mean to say," he asked, "that this sort of thing actually happens under capitalism?" "I certainly do," replied the workman. "But," persisted the inquirer, "did it ever actually happen to you?" "No," admitted the workman, "but it happened to a girl in our plant."

Things to Do

AIME and ASME Hold Joint Fuels Conference at French Lick

E. R. Price, Chairman, Coal Division, AIME

French Lick, Ind., is a particularly pleasant place in October. Plan to be at the French Lick Springs Hotel on the 26th and 27th. In addition to the usual inducements, the 12th annual joint meeting of the Coal Division, AIME, and the Fuels Division, ASME, will attract hundreds of engineers in the coal and fuel industries.

The opening session will be devoted to a symposium on the dewatering and drying of coal. You'll want to hear V. F. Parry and E. O. Wagner report on their experience in drying fine coal at the Bureau of Mines experiment station at Golden. F. P. Calhoun and E. C. Carris come next with two papers dealing specifically with flash drying. The symposium closes with a paper by J. L. Erisman on Coal Drying in Multi-Louvre Dryer.

Thursday morning will be devoted to a discussion of froth flotation of coarse coal particles by R. E. Zimmerman and S. C. Sun; a description of the laboratory control practiced at the mines of the Ayrshire Collieries by J. J. Merle and R. A. Mullins; and a paper by T. C. Spicer on the use of ignition baffles with single retort stokers.

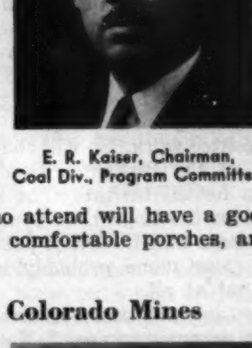
Thursday afternoon a trip is planned to the Maid Marion strip mine of the Central Indiana Coal Co., where visitors will be able to see some of the latest earth moving machinery and the operation of a coal dryer of R. G. Baughman's design. Mr. Baughman, who is general superintendent of preparation and construction for Central Indiana, is conducting the trip to the mine, some 35 miles from French Lick.

E. R. Kaiser, Chairman, Coal Div., Program Committee

Start making your plans now to attend the meeting. Registration blanks and further particulars will be sent to members of the two divisions about six weeks before the meeting.

While the principal attraction is presumed to be the technical sessions, experience in the past affords eloquent testimony that those who attend will have a good time on the golf course, comfortable porches, and in smoke-filled rooms.

75th Anniversary at Colorado Mines



Ben Parker, President, Colorado School of Mines

Ben Parker, president of the Colorado School of Mines, extends a cordial invitation to members of the AIME to attend the School's 75th anniversary of its founding on Sept. 20 to Oct. 1. Conferences on Friday and Saturday will include coal mining, geophysics, metallurgy, metal mining, geology, and several phases of the petroleum industry.

The Industrial Minerals Division of the AIME, is holding a session in conjunction with the celebration.

How to Get the Most From the Meeting

Attending a meeting profitably is the hardest kind of work; calls for a variety of skills; pays good dividends to the successful. The mind must go along with the body.

Every experienced meeting-attender has his own ideas on how to get the most out of the event. Here are a few from an observer's handbook.

Seek new contacts, unfamiliar ideas. A convention is a place where people come together for a purpose. Shun the people and you miss the purpose. To return empty-handed from any gathering is just as wasteful as to return empty-handed from a sales trip.

Neither pure extroverts nor pure introverts get the most out of conventions and meetings. One talks so much he doesn't hear much except the sound of his own voice. The other keeps to himself and hears nothing he couldn't read in some publication next week.

Listening closely to speakers is a small part of profit-taking from meetings. You must be trying, as well, to analyze, to poke holes in the statements; to translate the ideas into terms of your own problems.

Alert listening breeds questions, stimulates additional ideas. In discussion, ask those questions, express those ideas. A good session at a convention should be a sort of intellectual "Hellzapoppin'."

Make yourself available for committee activity. It often associates you with leaders; makes you important to your own organizations; gives invaluable experience in getting results through group cooperation. When you get back home, finish your convention-attending job. If your boss wasn't smart enough to ask for a memorandum about the meeting, write one anyhow. Fill it with facts, but point the meaning of each fact in relation to your company and your job.

Then you are through attending that meeting... and you will be glad of it! (Excerpts from "Getting Along With Others in Business," by N. G. Shidle.)

Personals

Horace M. Albright, president of the U. S. Potash Co., has been elected chairman of the National Minerals Advisory Committee, succeeding Donald H. McLaughlin, president of the Homestake Mining Co., and nominee for AIME President in 1950.

George M. Anderson, former Missouri School of Mines student, can now be reached at the Harbison-Walker Refractories Co., Fulton, Mo.

Robert W. Berkhahn has been employed as a metallurgist by the American Smelting and Refining Co. in El Paso, Texas.

T. P. (Josh) Billings has become consulting mining engineer for the U. S. Smelting Refining and Mining Co. **Arch G. Kirkland** succeeds him as manager of Western mines. Mr. Billings started his mining career in 1903 at Birmingham where he had charge of Tintic and Bingham operations of the Bingham Mines Co. In January 1929 he joined the U. S. Smelting organization as assistant to the manager of mines. Mr. Billings was given the position of manager of Utah mines in 1934 and in 1936 was advanced to assistant general manager of mines. He has been manager of Western mines since 1943.

Mr. Kirkland is a graduate of Queens University at Kingston, Ont. He was manager of Mic Mac Mines, Ltd., a subsidiary of the U. S. Smelting, for six years previous to his coming to Salt Lake City as assistant manager of western mines in February 1947 which followed the company's sale of the Mic Mac interest. In January 1949 he was made assistant manager of Western mines. Mr. Kirkland had been employed by the Hollinger Gold mines and Hard Rock Gold mines, both in Canada, before his Mic Mac position.

Louis S. Cates expected to go to Africa on July 31 and will be back some time in October.

Nicholas Chlumecky graduated last spring in mining engineering at the University of British Columbia, and is now with the Britannia Mining and Smelting Co., Britannia Beach, B. C.

Norman Cleaveland, formerly of Berkeley, Calif., has gone to Kuala Lumpur, Malaya, as manager of the Pacific Tin Consolidated Corp.

Clyde Williams (left) and Everette De Golyer out for a stroll in Washington. Our reporter notes "at least two ex-Presidents of AIME are able to perambulate."

Ward Carithers, who had been working for the Chelan division of the Howe Sound Co. in Holden, Wash., is currently mining geologist for the Calera Mining Co., Forney, Idaho.

Jack Christie has been made assistant underground manager of the N'Kana mine of the Rhokana Corp., Kitwe, N. Rhodesia. He started his mining career at the N'Kana mine fifteen years ago, with unbroken service. Last spring he visited the Witwatersrand gold mines and the Premier diamond mine, studying new mining methods.

John J. Collins, geologist with the U. S. Geological Survey, has taken up residence in Washington, D. C., at 2121 Virginia Ave., N.W. He has been assigned to the mineral resources section of the Survey, his project being an estimation of the resources and exploration possibilities for copper in the United States.

S. G. Lasky is chief of the newly created mineral resources section.

R. P. Connett, formerly with the Fredericktown Lead Co.'s Valle mines in Missouri, is now with the United States Gypsum Co. at Alabaster, Mich.

Forbes B. Cronk, after 44 years of continuous service, retired as general mining engineer of the Oliver Iron Mining Co. on July 1. He started work for Oliver as a mining engineer on the Mesabi, earning recognition of his capabilities that resulted in his becoming chief engineer of the Coleraine district in 1910. After correlating exploration and mining developments, he was transferred to Duluth headquarters as second assistant general mining engineer. His appointment as general mining engineer came in 1945. Mr. Cronk will continue with the Company in an advisory capacity.

H. W. deVriendt, who was a director of the Billiton tin smelter at Arnhem and an adviser of Billiton, has become general director of S. A. Belgochimie, Ghent, Belgium.

W. G. Donaldson has returned from Honduras after developing and equipping the San Andres Mine, a gold property owned by the New Idria Honduras Mining Co. in the western part of the country. The cyanide plant has a capacity of 250 tons per day and went into production last October. Mr. Donaldson now resides at 50 Alta Rd., Berkeley, Calif.

Tell Ertl is now a mining engineer with the Union Oil Co. of California, at Rifle, Colorado.

E. W. Felegy is now an assistant supervising engineer for District F, Safety Branch, Bureau of Mines in Duluth. His home address is 4842 London Rd., Duluth 4, Minn.

William T. Folwell is now mining engineer for the Hecla Mining Co., Burke, Idaho.

Glenn H. Fritz left the States in June for Calcutta, India, where he will represent the Joy Mfg. Co. Mr. Fritz joined the Company last fall, and underwent a period of intensive training in the application of Joy equipment to mining and tunnelling operations. Prior to joining Joy, he had been assistant engineer with Anaconda, training men for surveying and operating work at Butte. Mr. Fritz is no stranger to the Far East, having served with the USAF there during the recent war. Mrs. Fritz accompanied her husband to India, and they can be reached c/o Volkart Bros., Inc., 8 Netaji, Subhas Rd., Calcutta.

Louis Gence has resigned as manager of the Jean Felli Mica Mines, Bekily, Sud Madagascar, and is now connected with the Societe des Minerais de la Grande Ile as mine superintendent of their Ambatoabo mine

about forty miles northwest of Fort Dauphin, Madagascar.

John Griffen, coal preparation engineer with the Pittsburgh office of the McNally Pittsburgh Mfg. Corp., sailed on the Queen Elizabeth on July 15 for a two month inspection tour of European coal cleaning plants. He'll visit with government and private coal preparation specialists in England, France, Belgium, and the Netherlands.

George C. Heikes, formerly with the Kennecott Copper Corp., has gone to Athens, Greece, with the ECA. His address is ECA, Athens, APO 206, care of Postmaster, New York City.

Calendar of Coming Meetings

SEPTEMBER

- **12 Mid-Continent Section, AIME.**
- **14 El Paso Metals Section, AIME.**
- **15 Carlsbad Potash Section, AIME.**
- **15 North Pacific Section, AIME.**
- **15 Utah Section, AIME.**
- 15-16 Magnesium Association, Hotel Statler, Detroit.
- **16 Oregon Section, AIME.**
- **20 Gulf Coast Section, AIME.**
- **20 Washington, D. C., Section, AIME.**
- **21 Southwest Texas Section, AIME.**
- **26 Alaska Section, AIME.**
- **27 Montana Section, AIME.**
- 29 American Iron and Steel Institute, Hotel Statler, Buffalo.
- 25-28 American Mining Congress, Metal Mining Convention, Hotel Davenport, Spokane, Wash.
- **25-28 Mid-year Meeting, AIME, Neil House, Columbus, Ohio.**
- 29-30 ASME, fall meeting, Erie, Pa.
- 29-Oct. 1 Colorado School of Mines, 75th anniversary celebration.
- **Sept. 30-Oct. 1 Southern Ohio Section of Open Hearth Committee, AIME, fall meeting, Deshler-Wallick Hotel, Columbus.**

OCTOBER

- 3-4 National Assn. of Corrosion Engineers, Adolphus Hotel, Dallas, Texas.
- 3-6 Assn. of Iron and Steel Engineers, William Penn Hotel, Pittsburgh.
- **5-7 Petroleum Branch, AIME, fall meeting, Plaza Hotel, San Antonio, Texas.**
- 6 American Iron and Steel Institute, Drake Hotel, Chicago.
- 10-14 American Society for Testing Materials, Fairmont Hotel, San Francisco.
- 13-14 Texas Mid-Continent Oil and Gas Association, annual meeting, Rice Hotel, Houston.
- **14 Eastern Section, Open Hearth Committee, Iron and Steel Division, annual all-day fall meeting, Warwick Hotel, Philadelphia.**
- **14 Southwestern Section, Open Hearth Committee, Iron and Steel Division, Kansas City, Mo.**
- **17-19 Institute of Metals Division, AIME, fall meeting, Allerton Hotel, Cleveland.**
- 17-21 National Metal Congress and National Metal Exposition, Public Auditorium, Cleveland, Ohio.
- 17-21 American Society for Metals, annual meeting, Cleveland, Ohio.
- 17-21 American Welding Society, annual meeting, Cleveland, Ohio.
- 17-23 AIEE, 1949 Mid-West meeting, Netherland Plaza, Cincinnati.
- 19-20 Society for Non-Destructive Testing, Cleveland, Ohio.
- **20-21 Petroleum Branch, AIME, Elks Club, Los Angeles.**
- 24-28 Thirty-seventh National Safety Congress and Exposition, Chicago.
- **26-27 Joint Fuels Conference, ASME-AIME, French Lick Springs Hotel, French Lick, Ind.**
- **28 Pittsburgh Section of Open Hearth Committee and Pittsburgh Section, AIME, annual fall meeting, William Penn Hotel, Pittsburgh.**
- 28-29 ECPD, annual meeting, Edgewater Beach Hotel, Chicago.

NOVEMBER

- 1-5 Pacific Chemical Exposition, California Section, American Chemical Society, San Francisco Civic Auditorium.
- 2-4 American Society of Civil Engineers, fall meeting, Washington, D. C.
- 7-10 AIChE, annual meeting, Pittsburgh, Pa.
- 7-12 International congress on tunnel driving in rock formation, organized by the Societe de l'Industrie Minerale. Information on meeting available from French Mining Mission, 1322 18th St., N. W., Washington, D. C.
- **9-11 Industrial Minerals Division, AIME, Tampa, Fla.**
- 10-14 ASTM, first Pacific area national meeting, San Francisco, Calif.
- 12-14 Geological Society of America, annual meeting, Hotel Cortez, El Paso.
- **14 Arizona Section, AIME, annual meeting, Pioneer Hotel, Tucson, Ariz.**
- 16-18 Industrial Hygiene Foundation, 14th annual meeting, Mellon Institute, Pittsburgh.

DECEMBER

- 7 American Mining Congress, Annual Business Meeting, New York City.
- **8-10 Seventh Annual Conference, Electric Furnace Steel Committee, Iron and Steel Division, AIME, Hotel William Penn, Pittsburgh.**

JANUARY 1950

- 18-20 American Society of Civil Engineers, annual meeting, New York.
- 30 AIEE, winter meeting, New York.

FEBRUARY 1950

- **10 Southwestern Section, Open Hearth Steel Committee, Iron and Steel Division, St. Louis, Mo.**
- **12-16 Annual Meeting, AIME, Statler (Pennsylvania) Hotel, New York City.**

Samuel B. Kanowitz is eastern district manager of the Raymond pulverizer division of the Combustion Engineering Co., 200 Madison Ave., New York City.

Leon D. Keller resigned as chemist with the Sullivan Mining Co., Kellogg, Idaho, in March to accept a post as metallurgical engineer with The Dorr Co. He is engaged at present in doing heavy chemical and metallurgical research at the Westport mill of the Company.

Sherwin F. Kelly has been made chairman of the Geophysics Committee of the Canadian Institute of Mining and Metallurgy for the coming year.

George A. Kiersch is currently employed as engineering geologist by the Sacramento District, U. S. Corps of Engineers since resigning from the faculty of the Montana School of Mines. Dr. Kiersch spent over a year doing geological research connected with underground construction, and at present is resident geologist, Folsom Dam, where a large exploration program is underway. He resides at 4011 Berkshire Ave., Sacramento 17, Calif.

Paul P. Kraal is working for Bechtel Bros. Construction Co. at South Fork, Calif. His mailing address is Yosemite Forks, Oakhurst. He was working in the department of mining and metallurgy of the Twining Laboratories at Fresno.

Arnold B. Landstrom, mill superintendent for the Isle Royale Copper Co. until the firm ceased mining operations, has become associated with the research department of the Calumet & Hecla Consolidated Copper Co.

Thomas E. Luebben, research engineer with the Hegeler Zinc Co., Danville, Ill., was formerly with the Chicago-Harrisburg Coal Co.

Louis C. McCabe, former coal branch chief in the Bureau of Mines and for the last two years director of the Los Angeles, Calif., Air Pollution Control District, rejoined the Bureau on July 5 as chief of air and stream pollution prevention research. He will supervise work in this field and will assist the mineral industries in improving methods and devices designed to prevent the emission of harmful substances from mines, mills, smelters, and other installations. He will also serve as assistant chief of the fuels and explosives division under A. C. Fieldner, chief of the division. While on the West Coast Dr. McCabe was largely responsible for the progress recently made in developing ways and installing equipment designed to control hazardous air conditions around Los Angeles.

Hugh McKinstry is now serving as first vice-president of the Society of Economic Geologists. He is one of eleven AIME Members now directing the Society. The others are: **Olaf N. Rove**, Secretary; **J. T. Singewald, Jr.**, treasurer; and Councilors **Ernest F. Bean; Gilbert H. Cady; Carlton D. Hulin; Donald Davidson; William Callahan; Philip J. Shenon; Andrew Leith and John Gustafson.**

Arnold H. Miller, consulting engineer with offices in New York City, has been appointed by the board of directors as consulting engineer for the newly formed Cia. Minera Real de Plomosas, S.A. de C. V. Mr. Miller is at present in Sinaloa, Mexico, on work for the Company.

James J. Naughten is now employed as an assistant engineer with the engineering department of the Anaconda Copper Mining Co.

Earl K. Nixon took a three month leave of absence from the Kansas State Geological Survey during the summer to go to Alaska and the Yukon on private consulting work, evaluating mineral deposits of various kinds.

John C. Nixon received the degree of Doctor of Philosophy in metallurgy from the University of Utah last June for research on the theory of flotation. He is working at present for the Climax Molybdenum Co. in Climax, Colo., and hopes to return to his home in Australia before the end of the year.

Peter B. Nalle, after receiving his M.S. degree in mining from Columbia in January, started work for the St. Joseph Lead Co. at Bonne Terre.

Charles A. O'Connell is now underground manager, having been promoted from mine engineer, for Mufulira Copper Mines, Mufulira, Northern Rhodesia, S. Africa.

Edward B. Olds is addressed at the Bunker Hill & Sullivan Mining and Concentrating Co., Kellogg, Idaho. He had been with Consolidated Coppermines Corp.

T. A. O'Hara has changed his address from Bissett, Man., where he was employed by San Antonio Gold Mines, to Flin Flon, Man. He is now employed as mining engineer by the Hudson Bay Mining and Smelting Co. with work as assistant to the testing and ventilation engineers. He has been testing and reporting on the performance of the low carbon nickel alloys drill steel which the Company hopes will replace the present high carbon alloy drill steel in current use.

A. A. Parish, formerly with Australian Iron and Steel Ltd., has become works manager for Southern Portland Cement Ltd., limestone quarrying and cement manufacturing, Moss Vale, N.S.W., Australia.

D. W. Phillips has been appointed to the chair of mining at the New South Wales University of Technology, Broadway, Sydney, Australia.

Robert N. Pursel, after leaving military service in 1946, returned to Venezuela with the Texas Petroleum Co. where he was on the engineering staff. On June 16 he left for the Middle East for engineering work on the Trans Arabia Pipeline Company's pipe line from Saudi Arabia to the Mediterranean Sea. His new address is in care of the Company, P. O. 1348, Beirut, Lebanon.

Francis P. Williams, Jr.

Francis P. Williams, Jr., who graduated from Tri-State College last March with a degree in chemical engineering, is now employed as a chemist with the experimental division, Western Precipitation Corp., 1016 W. 9th St., Los Angeles, Calif. Before completing his college work, Mr. Williams had served for two years with the Navy in the Pacific, and prior to that, was with the Nevada-Massachusetts Co.

Thomas A. A. Quarm is no longer employed by the Frontino Gold Mines, Ltd., Antioquia, Colombia, where he was shift boss in charge of smelting. He is now with the Cerro de Pasco Copper Corp. as assistant research metallurgist. He receives mail at the Hotel Junin, La Oroya, Lima, Peru.

John G. Reilly has resigned his post as general manager of the Bayard department of the U. S. Smelting Refining and Mining Co. to become a consultant. He will continue to reside at 407 College Avenue, Silver City, N. Mex.

H. A. Quinn has returned from West Africa and resumed his former post on the geological staff of Norman W. Byrne, consulting mining engineer, at Yellowknife, N.W.T.

August F. Rambosek is now with the Phelps Dodge Corp. in Tyronne, New Mexico, having moved there from Park City, Utah. Mr. Rambosek, who was married a few months ago, is a graduate of the Montana School of Mines.

Francis F. Redfield has returned to the States from Aguilar, Argentina, and is now working as a mining engineer with the St. Joseph Lead Co.

John J. Reed in September of 1947 was transferred by the Braden Copper Co. from his post as assistant mine foreman and since that time has been field engineer in the hydraulic division of the electrical department. His present work involves the operation, maintenance, and construction of the extensive hydro electric power system developed by Braden. Recently, Mr. Reed returned to Chile after spending a four month vacation with his family.

John A. Riddle, after graduation from the Colorado School of Mines in May, took the job of an engineering trainee with the Oliver Iron Mining Co., Coleraine, Minn.

John A. Riley was named president of the Colombian Development Corp., New York City, at the concern's May board meeting.

Vernon J. Rogers, formerly at Washington State College, is now field assistant with the U. S. Geological Survey and receives his mail at General Delivery, Bozeman, Mont.

Robert L. Root completed the course in mining geology at the Missouri School of Mines and Metallurgy in January and is now working as assistant engineer and geologist for the International Smelting and Refining Co.

John W. F. Rudnicki received a B.S. degree in mining engineering in 1948 from Lehigh and a B.S. in civil engineering from the same university this February. His present post is field engineer in the Chesapeake and Ohio Railway coal development department in Huntington, W. Va.

Carl F. Schaber is now with the Mackenzie Engineering Co., 8 Dake St.,Manchester Square, London W-1, as resident engineer in charge of building the new 500,000 ton steel plant in Yugoslavia. He had been a member of the staff of H. A. Brassert & Co. His permanent address remains at 500 S. Tin Ave., Deming, N. Mex.

Edward A. Sawitzke is now an engineer with the E. J. Longyear Co., Minneapolis, Minn., having left his post as secretary and vice-president of the Diamond Drilling Co. In his new job, he's working on the Fried-

ensville shaft in Friedensville, Pa. Letters reach him at Box 54, Center Valley, Pa.

A. H. Shoemaker, general manager of the Triumph Mining Co., was elected president of the Idaho Mining Ass'n at its annual meeting in June. At the same time **Henry L. Day**, president and general manager of Day Mines, Inc., was elected vice-president of the Association, and **Harry W. Marsh** of Boise was re-elected secretary. **Harry D. Bailey** of Stibnite, resident manager of the Bradley Mining Co., and **J. C. Kieffer** of Kellogg, manager of the Spokane-Idaho Mining Co., will serve as two of the four directors elected for the forthcoming year.

E. Nelson Strang, who graduated in June from Lafayette College, and who was president of the John Markle Society at that school, is now a mine inspector for the Stonega Coal and Coke Co. in Big Stone Gap, Va. Mr. Strang was a transitman for the mine from 1938 to 1942, and during his summer vacations in 1946, '47 and '48.

At the Rio Conference

When the First Pan American Engineering Congress met in Rio de Janeiro from July 15 to 24th, there were fourteen AIME Members there to present technical papers. Those who attended were:

T. G. MacKenzie, who collaborated on a paper on the economics of power development in Latin America; **Richard J. Lund**, who presented his paper on "Stockpiling in the U. S.—Past, Present and Future" (which appeared in the August issue of ME); **Sherwin F. Kelly**, who spoke on geophysical methods applied to exploration for ground water supplies; **J. H. Evans**, "Geophysical Explorations for Mineral Deposits"; **H. W. Straley, III**, "Copper Deposits of the Western Hemisphere"; **R. L. Anderson**, "Trends in Mechanical Loading and Strip Mining of Bituminous Coal"; **W. A. Leech, Jr.**, "By-Product Coking"; **Richard M. Foose**, "Photogeology—A Tool for Mineral Development"; **A. M. Bateman**, "America's Stake in the Mineral Resources of the World" (which appeared in the July issue of ME); **J. M. Wolfe** and **Fred T. Agthe**, "Modern Portland Cement Practice"; **Harry H. Power**, "Petroleum Engineering Education and the Quantitative Approach"; **John A. Ruppert, Jr.**, and **John E. Conley**, "Developments in the Manufacture of Lightweight Aggregates"; and **Carl W. Westphal**, "Modern Mechanical Methods in the Chemical and Processing Industries."

George M. Potter

George M. Potter has completed his one year assignment with the Foreign Minerals Branch of the Bureau of Mines in Mexico and has returned to the Salt Lake City branch of the metallurgical division. His new address is Bureau of Mines, 1600 E. First S. St., Salt Lake City 1.

Herbert C. Schweitzer is with the Molybdenite Corp. of Canada, La Corne, Val D'or, Que. He was previously employed by the Associated Metals and Minerals Corp.

Robert H. Shepard graduated in June from Brooklyn College with a B.S. degree in geology. He is employed at present in the mineral classification branch, conservation division, of the U. S. Geological Survey. He can be addressed care of the Survey, P. O. Box 997, Roswell, N. Mex.

Robert L. Swain became assistant chief mine engineer of the Braden Copper Co., Rancagua, Chile, and can be reached at the mine staff house, care of the Company. He had been with the Consolidated Coppermines Corp.

John S. Sumner, who recently graduated from the University of Minnesota with a B.S. degree in geology and physics, is now working as an assistant geologist with the Cleveland-Cliffs Iron Co., Ishpeming, Mich.

H. A. Toelle, Jr., can be reached in care of the Braden Copper Co., Rancagua, Chile. He had been addressed at Michigan College of Mining and Technology.

Paul M. Tyler is now in Europe studying ECA activities as part of his new position as minerals consultant for the Joint Congressional Committee on Foreign Economic Cooperation. He expects to visit several projects in the Near East and Africa, and then return to Washington in the fall.

William Huff Wagner, consulting engineer, is now secretary of the new Committee on Engineers in Civil Service of the Engineers Joint Council. The five-man Committee is composed of representatives from ASCE, ASChE, ASME, AIEE, and AIME, represented by Mr. Wagner. Its function is to maintain close liaison with the U. S. Civil Service Commission and other Federal agencies, in order to provide closer cooperation between the government and the 100,000 members of the four Founder Societies and the AIChE. Questions such as those of job standards and qualifications of government-employed engineers will form an important part of the Committee's work. Present headquarters are in the Washington offices of the ASCE.

Louis Ware, president of the International Minerals and Chemical Corp., sailed for Europe on July 12th for a two month business trip, with the object of studying economic conditions on the Continent and inspecting French and German potash mines in which his company has interests. Accompanied by Mrs. Ware, Mr. Ware visited European agents and customers of the Company.

Woodrow W. West has been appointed chief sales engineer for the Pennsylvania Crusher Company's division of bath iron works in Philadelphia. Mr. West has been with the company for seven years, working up through engineering, testing, shop inspection, and sales. He had a part in engineering and designing the Reversible impactor, a device which has begun to replace the standard type hammermill in the cement and stone industries. Mr. West has studied engineering at both Indiana Technical College and Temple University.

G. M. Wiles has been appointed division manager of the St. Louis smelting and refining division of the National Lead Co., and **A. R. Reiser** has been named as his assistant. At the same time, two other executive changes have made **H. A. Krueger** plant manager of the Tri-State operations of the division, and **A. J. Yahn** plant manager of the division's FredErickstown operation. Other changes in the Company now find **Frank R. Milliken** serving as assistant manager of National Lead's Titanium Division, with headquarters in New York; **George W. Wunder** succeeding Mr. Milliken as manager of the MacIntyre development in Tahawus, N. Y.; and **Paul W. Allen** becoming assistant plant manager at that site.

J. H. Williams is now a fuel engineer on the staff of the Fairmont Coal Bureau. During the early years

of his career he was closely connected with the bituminous coal industry as a test engineer in Cleveland, and during the war engineered and operated several Ordnance Division plants. He has been a consulting engineer in the power field since that time.

Sidney E. Worthen is now a sectional engineer for Patino Mines and Enterprises Cons., and can be reached at Llallagua, Bolivia, S.A.

—In the Metals Branch—

Robert K. Allen and **Alvin H. Kasberg,** both seniors in the department of metallurgy at the University of Wisconsin, took top honors in this year's James F. Lincoln Arc Welding Foundation undergraduate awards, with their paper entitled "A Study of the Welding Characteristics of Aluminum Bronze Electrodes." The award, made on July 9, was $1,000, and, in addition, an equal amount was presented to the University to establish four annual scholarships of $250, to be known as the Robert K. Allen, Alvin H. Kasberg-Lincoln Foundation Scholarship. The award formed part of scholarships totalling $6750 presented to three schools, and to 77 undergraduates in 47 engineering schools, which prizes are designed to stimulate engineering undergraduates to aid in the development of the science of arc welding.

George Allison is working at Dumas, Texas, as plant metallurgist for the American Zinc Co. of Illinois.

J. K. L. Andersen since June 1 has been employed as assistant to the director of A/S Bremanger Kraftselskap, a pig iron plant, boks 524, Bergen, Norway.

Edward L. AuBuchon, since his graduation from the Missouri School of Mines last May, has taken the job of open-hearth metallurgist with the Wisconsin Steel Works, Chicago. His address is 10232 S. Ave. J, Chicago 17.

Edgar C. Bain, vice-president of the Carnegie-Illinois Steel Co., will receive the 1949 Gold Medal of the American Society for Metals at the annual dinner of the Society on Oct. 20 at the Hotel Statler, Cleveland. Dr. Bain receives this, one of the highest honors made available in the metals industry, in recognition of his great versatility in applying science to the metal industry.

George M. Baumann has been made purchasing agent and assistant to the plant manager of the Whiting plant, Federated Metals Division, American Smelting and Refining Co. Associated with Federated Metals since 1936, he has served in various capacities in various plants in the States and in Mexico. For the past three years he had been assistant to the general manager of scrap purchases at the Company's headquarters in New York City.

J. H. Bechtold is research metallurgist for the Westinghouse Research Laboratories at East Pittsburgh, Pa. His address is 5801 Aylesboro Ave., Pittsburgh 17.

George A. Bivens, having graduated from the University of Michigan, is a junior engineer with the Worthington Pump and Machinery Corp., Harrison, N. J.

John B. Campbell is associate editor of **Materials and Methods,** Reinhold Publishing Corp., 330 W. 42nd St., New York City 18.

Kenneth L. M. Dodd is now managing the Vancouver office of Canadian Allis-Chalmers, Ltd. He was formerly a field engineer with the Denver Equipment Co.

Harley S. Van Fleet

Harley S. Van Fleet has been appointed manager of Atlantic division research for the American Can Co., with headquarters in New York City. He was formerly chief of the container research section at the Company's general research laboratory.

John F. Elliott is now with the research laboratories of the U. S. Steel Corp. in Kearny, N. J. Mr. Elliott took his Sc.D. degree in metallurgy from MIT in June, having written his doctor's thesis on "The Thermodynamic Properties of Liquid Metallic Solutions."

George Enzian became assistant manager of metallurgical research of the Jones & Laughlin Steel Corp., Pittsburgh, on May 1. He is secretary of the Pittsburgh Section, AIME, as well as being active in the Pittsburgh Local Section of the Open Hearth Committee.

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Carl Zapffe

Carl A. Zapffe and **Miss M. E. Haslem** have been awarded a Certificate of Honorable Mention by the Wire Association for presenting the outstanding paper in the ferrous division of that industry in 1948. The paper described the discovery that hydrogen gas is absorbed by certain steels from inhibited pickling solutions in quantities as great as from uninhibited acids, causing important damage which has previously been blamed on other factors. Dr. Zapffe and Miss Haslem will receive the award at the annual banquet of the Wire Assn. in Chicago on Oct. 19.

Arthur E. Focke, research metallurgist for the Diamond Chain Co., Indianapolis, has been nominated to serve for one year beginning next fall as president of the American Society for Metals. **Elmer Gammeter,** chief metallurgist for Globe Steel Tubes Co. of Milwaukee, has been nominated to the board of trustees for a two-year term. Dr. Focke is a graduate of Ohio State University, where he also received his M.S. and Ph.D. degrees. Prior to his Diamond Chain affiliation, which began in 1930, he had been special metallurgist for General Electric Co. and chief engineer for P. R. Mallory Co. Mr. Gammeter, an employee of Glove Steel Tubes since 1943, had previously been manager of the stainless steel bureau, metallurgical division, Carnegie-Illinois Steel Corp. in Chicago, which followed six years as metallurgist for Edison General Electric Appliance Co.

O. B. J. Fraser, of the International Nickel Co. in New York, has been named president of the American Welding Society for the coming year.

Norman C. Jensen is an engineer with Consolidated Builders, Inc., at

the Detroit Dam. His new address is Box 515, Mill City, Oreg.

David W. Levinson has been appointed an instructor in the department of metallurgical engineering at Illinois Institute of Technology in Chicago. Mr. Levinson, who assumed his new duties on Sept. 1, took his master's degree at Tech last June, and received his bachelor's degree in February of last year. He will work under **Otto Zmeskal,** director of the department at the school.

S. C. Massari has been awarded the John H. Whiting Gold Medal of the American Foundrymen's Society, for "outstanding contributions in the field of ferrous metallurgy, molding and foundry practice and service to the wartime foundry industry with the Chicago Ordnance District." Mr. Massari is technical director of the AFS and was for 18 years research metallurgist for the Association of Chilled Car Wheel Mfrs.

Donald J. McMaster is a trainee in the remelt division of the Permanente Metals Corp. at Trentwood, Wash. His address there is N4501 Bannon Ct.

Ralph W. Preston, Jr., is now employed by the Timken Roller Bearing Co. as a metallurgist trainee. He can be reached at the YMCA, 405 2nd St., N.W., Canton 2, Ohio.

Raymond A. Quadt has been appointed director of aluminum development for the Federated Metals Division of the American Smelting and Refining Co. in Detroit. Mr. Quadt, who was formerly assistant manager of the firm's general aluminum department, will continue his extensive aluminum research in his new position – which research has already led to the development of Tenzaloy.

Gilbert Soler, of the Iron and Steel Division, AIME, is now vice-president of manufacturing operations for Atlas Steels, Ltd., Welland, Ont., Canada. He was formerly works manager for the Company.

J. C. Warner, dean of graduate studies and head of the chemistry department at Carnegie Institute of Technology, has been named president-elect of Carnegie Institute. He will fill a newly created office of vice-president until his inauguration after the present president retires on July 1, 1950. Dr. Warner's election climaxes 23 years of outstanding service on the Carnegie faculty. Starting out as an instructor in chemistry in 1926, he advanced up the academic ranks to become professor of chemistry and head of that department in 1938 and dean of graduate studies in 1945. On a two-year war leave from the campus, as one of the nation-wide team of scientists which turned out the atomic bomb, he directed and co-ordinated research in the laboratories at the Universities of California and Chicago, Iowa State, MIT, and at Los Alamos, in highly confidential work on the purification of plutonium.

—In Petroleum Circles—

R. C. "Bob" Chenoweth has become manager of machinery sales for the Republic Supply Co. with headquarters in Houston. He has been engaged in the sales of machinery to

R. C. Chenoweth

the oil industry since 1929, at which time he started selling pumps in the Mid-Continent territory following graduation in mechanical engineering from Purdue. Since 1939 he has been located in Houston and has represented several of the large machinery accounts in the Gulf Coast and Mexico areas.

Rodney R. Adams has finished his schooling at the University of New Hampshire and is working for the Seismograph Service Corp. of Tulsa.

Ralph F. Atkinson is a junior engineer in the production department of the British American Oil Co. in Edmonton, Alta.

James R. Cameron has joined the research staff of Battelle Memorial Institute, Columbus, Ohio, where he is doing research in nonferrous metallurgy. An Ohio State graduate, he was associated with the Stanolind Oil and Gas Co. in Gorham, Kans., before taking this job.

John M. Cooper is assistant managing director of the Kuwait Oil Co. with offices at 1 Great Cumberland Place, London W1, England. He had been with the Gulf Oil Corp. in Houston.

W. F. Dalton, who was chief engineer of the Hunt Oil Co., is now president of the Placid Oil Co., Shreveport, La.

Donald M. Davidson has been elected vice-president of the E. J. Longyear Co., Minneapolis, diamond drill contractors and manufacturers.

Thornton Davis, president of the Linda Petroleum Co., San Antonio 5, Texas, was formerly vice-president and manager of the Peerless Oil and Gas Co.

Everette L. De Golyer received an honorary degree of Doctor of Engineering at Princeton University's 202nd annual commencement on June 14. The citation characterized him as "a geologist and oil producer whose international reputation in the field of petroleum engineering is unexcelled," as well as "a prospector in the discovery of human abilities."

Elmer L. DeMaris is supervisor of exploration for the General Petroleum Corp., Box 2122, Terminal Annex, Los Angeles 54, Calif.

E. G. Dobson has been transferred to the post of chief petroleum engineer of the Texas Petroleum Co., Caracas, Venezuela. He had been in Bogota, Colombia.

William F. Ellis is assistant petroleum engineer with the Union Producing Co., P. O. Box 872, Vivian, La.

Glen E. Emmett, having graduated from Texas Technological College, has taken the job of engineer revenue agent with the Bureau of Internal Revenue. His new address is 2159 Lovedale Ave., Dallas 9, Texas.

L. W. Fagg is a partner in the Johnson-Fagg Engineering Co., 4020 S. Peoria Ave., Tulsa 5, Okla.

George H. Fentress is now a technical trainee in the geophysics section of the Phillips Petroleum Co. He received his degree in geological engineering from the Colorado School of Mines last May.

Ray L. Freeborn, who is with the Continental Oil Co., has been moved from Wichita Falls, Texas, to serve as district engineer in the organization's New Mexican District. He is addressed care of the Company, Box CC, Hobbs, N. Mex.

John C. Gallivan is now production superintendent for the Wood River Oil and Refining Co., with offices at 2527 20th St., Great Bend, Kans.

James H. Galloway is now district superintendent for the Humble Oil and Refining Co., at 612 S. Flower St., Los Angeles, Calif.

E. A. Galvin has joined the Western Gulf Oil Co., 1260 Terminal Bldg., Los Angeles, Calif., as chief production engineer.

Alvin A. Geyer, who had been studying at Louisiana State, is now a roustabout engineer with the Pan American Gas Co. at Texas City, Texas.

David Goodwill is now a production analyst in the production department of the Standard Oil Co. of California, at Box 151, Whittier, Calif.

Ralph C. Graham, who was chief geologist with the Tennessee Gas and Transmission Co., is vice-president of the Coast Co., P. O. Box 1181, Houston.

George H. Gray of Midland, Texas, has become division engineer for the Sinclair Prairie Oil Co., at P. O. Box 1470 in that city.

Russell W. Haller, after graduation from the University of Pittsburgh, joined the Continental Oil Co. as an engineer trainee. He is now working at the Company's Gebo, Wyo., field. Mr. Haller is addressed care of the Company, Thermopolis, Wyo.

Harold H. Knapp is a trainee engineer with the Ohio Oil Co. at Eureka, Kans. He had been a student at the University of Tulsa.

Dan Kralis has become manager of exploration and assistant to the president of the Sunland Refining Corp., in Fresno, Calif. He heads the newly-formed division of exploration for the Company, and is carrying out development and exploration work in Texas, the Rockies, California and Nevada. Mr. Kralis was formerly with the Petroleum Exploration Service, a consulting firm, as chief geologist. His new home address is 1307 Dakota Ave., Fresno.

Jean Warren Meyers, formerly with the Stanolind Oil and Gas Co., is working for the Champlin Refining Co., Ellinwood, Kans., as a petroleum engineer.

Paul O. Naut, no longer a student at Oklahoma University, is an engineering trainee with the Creole Petroleum Corp. at Tia Juana, Zulia, Venezuela.

John A. Poulin can be addressed Oil and Gas Division, Foreign Branch, U. S. Dept. of the Interior, Washington 25, D. C.

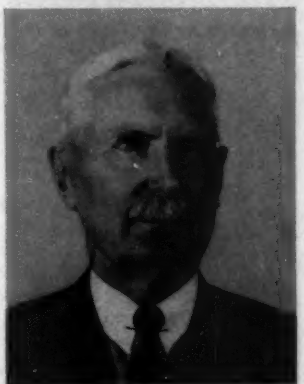
Joe Lee Terry is now with the geological department of the Houston Oil Co. of Texas, in Houston.

Lyon F. Terry has been made vice-president of the petroleum department of the Chase National Bank.

E. V. Watts has been appointed production superintendent of the Southern Division of the General Petroleum Corp.'s production department. He had been assistant to the southern division superintendent since May of last year. Mr. Watts has been with the Company since his graduation from the California Institute of Technology in 1936, when he began as a roustabout in the Lost Hills field. His home address is 529 Garfield Ave., S. Pasadena, Calif.

Obituaries

ROBERT H. JEFFREY (Member 1896) British-born mining engineer who had spent most of his career in Mexico, died on Jan. 31, at the age of 75. Mr. Jeffrey was a graduate of the Royal School of Mines in England, and began his professional career in this country at mines in Virginia and Arizona. In 1898 he joined the Pinos Altos Co., in Chihuahua, Mexico, later working for the Avino Mines, Ltd., in Durango, and then beginning an unbroken association with the Mazapil Copper Co. in Saltillo, Coahuila. He retired in 1927, but was soon recalled, and made a director of the Company the following year. He also served as director of four railroads in Mexico. For many years Mr. Jeffrey served as British Vice-Consul in Saltillo, and, in 1914, when the U. S. troops entered Vera Cruz, he was in charge of the U. S. consulate there. Mr. Jeffrey claimed to have installed the first flotation table in Mexico, and had patents on both the Jeffrey automatic feeder and the Jeffrey concentrator.



Robert H. Jeffrey

James MacNaughton

An Appreciation by C. Harry Benedict

James MacNaughton, former president of the Calumet & Hecla Consolidated Copper Co., died at his home in Calumet on May 26. He was eighty-five years old and had been seriously ill for some years.

Mr. MacNaughton has taken an active part in Institute affairs throughout his professional career. Elected to membership in 1890, he was one of the oldest members of the Legion of Honor. From 1916 to 1918 he served as vice-president and in 1935 was the recipient of the William Lawrence Saunders medal.

Born March 9, 1864, at Bruce Mines, Ont., Canada, Mr. MacNaughton was brought to the Michigan copper country at the early age of three months. His father took employment with the newly opened and rapidly developing Calumet & Hecla Mining companies, distinct corporations at that time, constructing milling facilities at Lake Linden. Young James himself at the age of eleven worked as water boy for the same company during his vacation, and again five years later at the completion of his primary education, as a stationary engineer.

His college career consisted of one year residence at Oberlin, followed by an engineering course at the University of Michigan from which he received the degree of B.S. in Civil Engineering with the class of 1888. In 1930 he was awarded the honorary degree of Doctor of Science by the Michigan College of Mining & Technology, on whose Board of Control he served for many years. But most of his education came from detailed experience in the field.

His rise in the mining world was a rapid one. After leaving college he returned first to his beloved Calumet & Hecla for a short time as junior engineer and in 1889 accepted a corresponding position with the Chapin mine at Iron Mountain, Mich. Within three years he was general manager of the Chapin and under his direction it became the largest producer of iron ore in the state, and equally famous for its efficiency and low cost of operation. He remained at the Chapin for twelve years.

At the turn of the century the Calumet & Hecla Copper Co. was facing a deepening and declining yield ore-body and Alexander Agassiz, president of that company, was looking about for a new manager to take charge. Mr. MacNaughton was a natural choice but it was a difficult decision for him to make in accepting the offer, for the iron ore industry was then entering a tremendous expansion. But Calumet was his home and the Calumet & Hecla his first love, and so in 1901 he came back as superintendent to the company from which he had earned his first dollar as water boy twenty-five years previously—truly an American saga.

Mr. MacNaughton had full responsibility for all operations at Calumet, many functions before his time having been taken care of at Boston. For forty years, under successive titles of general manager, vice-president and president, he guided the destinies of the company through an expansion period from the operation of a single mine to an integrated company with mining territory extending throughout three counties and employing more than 12,500 men. Under his leadership and because of the confidence that other mining and financial leaders reposed in him, the Calumet & Hecla for many years had a standing in industry out of proportion to its copper production.

In politics he was a staunch Republican and as such was a number of times delegate to Republican national conven-

tions and in 1900 a presidential elector. As befalls to all busy men Mr. MacNaughton devoted much of his time to civic and charitable activities in behalf of his employees and the community of which they and their families were the major part. His private beneficences were unostentatious, in keeping with his character.

The secret of Mr. MacNaughton's success as an executive and a leader of men lay in an engaging personality, a keen sense of humor, an uncanny ability to make rapid and correct decisions, and above all personal integrity. He had an inexhaustible fund of stories, mild for the ladies and pungent for the locker room. A pert phrase or the very pointed moral of a short story was used more often than heated argument to settle a controversy or gloss over a departmental dispute. Whether as considerate superior, genial host, or entertaining guest, his kindly nature will be long remembered and cherished by his neighbors and friends in the Copper Country, and his associates throughout the nation.

ROBERT HARDY BEDFORD (Member 1948), died in Los Gatos, Calif., on April 26, at the age of 66. Mr. Bedford, a consulting engineer, was born in New Zealand, and had a degree in general science from the University of New Zealand. He also attended the University of Missouri, receiving his B.Sc. degree from there in 1906, and an E.M. five years later. After several years in copper mining in Bisbee and Globe, Ariz., he became superintendent of the North Star mines in Grass Valley, Calif., remaining there for fifteen years. Mr. Bedford then set up a consulting practice, and was a consultant on gold mining for the Russian government during 1930-32. At the time of his death, he was a consultant for the Yellow Jacket Mining Co.

CHARLES A. BRUCE (Member 1948), a petroleum engineer, died on March 11 at Weeks Island, La., of accidental drowning. He was 28 years old. Mr. Bruce entered the Missouri School of Mines and Metallurgy in 1939, but his education was interrupted two years later, when he went to serve for four years in the Navy Air Corps. He took his B.S. degree in 1947, and was employed, at the time of his death, by the Shell Oil Co.

WILLIAM H. CORBOULD (Member 1892), a leading figure in Australian mining, and a Life Member of the AIME, died on March 16, at the age of 82. Mr. Corbould, a mining engineer and metallurgical chemist, was educated at Ballarat College, worked on the Broken Hill silver fields in 1885, and later traveled through England, Austria, Japan, France, Canada, Germany, and China as well as the U. S. A., studying mining geological formations, and metallurgical works.

In 1893 he walked from Freemantle, in Western Australia, to the Coolgardie goldfields, a distance of 300 miles. It was this sort of determination which made him the directing spirit of Mt. Isa Mines, Ltd., in its early period. Mr. Corbould had the technical knowledge plus sufficient imagination to see the wealth of Mt. Isa's ore, and went on to implement his realization that only millions of dollars could successfully exploit the low-grade deposits. The organization which he so successfully brought to the world's attention is now worth more than $17,000,000, exclusive of the ore bodies, the extent of which has not yet been delimited.

William J. Flori

WILLIAM J. FLORI (Member 1948), a junior mining engineer for the Miami Copper Co., died on May 7, at the age of 25. Mr. Flori attended Blackburn College from 1941 to 1943, and in that year became an aviation cadet in the U. S. Navy Air Corps. He rose to the rank of Ensign, was discharged in 1946, and completed his professional education at the Missouri School of Mines in June of last year. It was then that he joined Miami Copper.

R. CLYDE BUTLER (Member 1947), vice-president in charge of operations of the Empire Steel Co., died on March 28 at the age of 56. Mr. Butler was a native of Ohio, and graduated from Youngstown College in 1916. For four years he was a chemist for the Ohio Iron and Steel Co., then joined the Sharon Steel Corp., where he served for fourteen years as assistant superintendent of blast furnaces. In 1936 he joined the Pittsburgh Steel Co. as superintendent of blast furnaces, and moved up, within ten years, to the position of general manager for the firm. He was with the Steel Co. of Canada for a time before joining Empire Steel.

Necrology

Date Elected	Name	Date of Death
1920	John R. Comstock	July 14, 1949
1913	Emil Gathmann, Sr.	Aug. 23, 1949
1918	Joseph S. Henry	March 26, 1949
1937	Louis W. Huber	Aug. 17, 1949
1928	William D. Mark	June 16, 1949

JOSEPH P. LABAW (Member 1920), consulting mining engineer of Hopewell, N. J., died on April 27. He was 69 years old. Mr. Labaw received his degree in mining engineering from the Michigan College of Mines in 1903, and went on to work with many mining companies in all parts of this nation before he began his own consulting practice. His consulting work took him through Mexico, Canada, South America, and Costa Rica. His last position, before a heart condition forced him from more active work, was with the U. S. Metals Reserve, in the bauxite area of Arkansas, during the recent war.

JAMES E. LITTLE (Member 1909), formerly with the mining department of the Bethlehem Steel Co., died on May 24 after a brief illness. He was a graduate of Lehigh University, class of 1894, with a degree in mechanical engineering. His first eight years were spent with the Bethlehem Iron Co., predecessor of Bethlehem Steel. In 1902 he went with the Pennsylvania Steel Co., serving for ten years as a mechanical engineer with their Cuban subsidiary, the Spanish American Iron Co. As such, he engineered the mine development and shipping facilities at the Mayari iron ore deposits in Felton, Cuba. When the Company was acquired by Bethlehem Steel in 1916, he moved to Bethlehem, serving in the mining department until 1940, and in the research department until 1947, at which time he retired.

CARL H. LOUX (Member 1920), mining engineer and former superintendent for the Alan Wood Steel Co., Conshohocken, Pa., died on March 31, at the age of 60. Born in Idaho, Mr. Loux had studied at the University of California, and graduated in 1912 from the University of Idaho. Mr. Loux's early years were spent at various properties in Idaho, Montana, and up in Canada. At one time he had been assistant city engineer for the city of Pocatello, Idaho. Later he worked as a chemist for Anaconda, as an oil geologist for the Northern Pacific Railroad, and as superintendent for the Warren Foundry and Pipe Corp. in Oxford, N. J. He had also done special investigation of ore classifications at Anaconda, and designed a new mining method for the Washington mine in Oxford, N. J.

LEONARD LYNCH (Member 1947), a metallographist with the Wisconsin Steel Works of the International Harvester Co., died last Oct. 18 at the age of 35. Mr. Lynch attended Hibbing and Itasca Junior Colleges, and took a bachelor of chemistry degree from the University of Minnesota in 1936. The following year, he joined the McCormick works of International Harvester, and became control metallurgist and metallographist at the steel works in 1941.

William Clifton Phalen

An Appreciation by Oliver Bowles

W. C. Phalen, a member of the Institute since 1912, passed on at his home in Washington, D. C., on May 27, 1949. Born at Gloucester, Mass., in 1877, he received his B.S. degree in chemistry and M. S. in geology at MIT. He later was awarded a Ph.D. degree at George Washington University. He began his scientific career at the National Museum in 1902, and joined the staff of the U. S. Geological Survey in 1904. He served as a mineral technologist for the Bureau of Mines from 1916 to 1920. Part of this period was devoted to problems of strategic minerals essential to the conduct of the first World War.

Dr. Phalen's specialty was saline minerals, and because of his comprehensive knowledge of them he left the Bureau of Mines to become the salt specialist of the Solvay Process Co. at Syracuse, N. Y., which he served efficiently until his retirement in 1946. He was a part-time consultant for the Bureau of Mines at the time of his death.

Although quiet and unobtrusive, Dr. Phalen possessed a wealth of information on salines as well as on geology, mining, and chemistry in general. His wide knowledge, integrity, and quiet humor, attractive personality and loyal friendship endeared him to all of his associates.

E. PAUL KEUPER (Student 1948), a junior at the University of Cincinnati, died last December. Mr. Keuper, who was 21, expected to take his B.S. in metallurgical engineering in 1950.

CHARLES MENTZEL (Member 1909), a consulting mining engineer, died in New York City on June 1, at the age of sixty-seven. Since his graduation in 1907 from the Columbia School of Mines, Mr. Mentzel had been with mining enterprises in Canada, the Western United States, Mexico, and Panama. In 1914, he was a mine examiner for the Canadian government, and later, served in the same capacity in Mexico. In 1915, he opened manganese deposits in Mandinga Bay on the Gulf of San Blas, Panama. Mr. Mentzel was generally regarded as an expert on emeralds.

ARTHUR BERKELEY YATES (Member 1938), former chief geologist of the International Nickel Co., died in Montreal on May 10 at the age of 47. He had come to that city from South Africa to receive the Barlow Memorial Medal of the Canadian Institute of Mining and Metallurgy at their recent annual meeting.

Born in Lead, S. Dak., Dr. Yates took his B.Sc. from the University of California in 1922, and the M.Sc. and D.Sc. degrees from Harvard nine years later. From 1923-28 he was a surveyor, engineer, and geologist for the Homestake Mining Co. Following two years as a research associate at Harvard, Dr. Yates joined International Nickel.

Arthur Berkeley Yates

He was a member of the CIM, a fellow of the Royal Society of Canada, and a member of the Society of Economic Geologists, and the Geological Society of America.

Harry H. Stout

AN APPRECIATION BY DONALD M. LIDDELL

Harry H. Stout died in Plainfield, N. J., on April 13, aged 76 years and four months, after a long, complicated illness, chiefly a severe arthritic condition. He was born in Sacaton, Ariz., Dec. 8, 1872. In 1878, his parents moved to Tidioute, Pa., and he entered the United States Military Academy in 1891 from Pennsylvania, graduating in 1895 and serving as Lieutenant in the Sixth Cavalry in the Spanish-American War. He resigned from the Army in 1901, and entered the chemical business in California, residing in San Francisco and Berkeley and serving as superintendent for the Peyton and the General Chemical Companies.

He was an ordnance officer with the American Expeditionary Force in France in World War I and was commended officially by General John J. Pershing. He became chief metallurgist for Phelps Dodge in 1921 and retired in 1931. The rejuvenation of the Nichols Copper works was one of his achievements. Before his retirement, he had lived at Ardsley-on-the-Hudson but moved shortly afterward to Plainfield.

He had been a member of the AIME for about 32 years. The Secretary remembers a session at the Engineers' Club with the late Colonel Barbour and Colonel Stout on the eve of his sailing for France in World War I and Colonel Stout's writing down an equation: the value of an engineer $=$ professional knowledge $\times$ honesty^2 $\times$ guts^3 $\times$ loyalty^4.

He had these qualities without the necessity of any exponents.

HUBERT MERRYWEATHER (Member 1916), retired Bethlehem Steel Co. executive, died of a heart attack on June 7, at the age of 67. When he retired in 1947, Mr. Merryweather was general manager of ore properties for the Company, having been with Bethlehem Steel for 36 years. After graduating from MIT in 1904, he spent six years in mining activities in the West and at various sites in Mexico. Then he took over as mine superintendent for Bethlehem's Juragua Iron Mines Co., in Cuba. After three years he was sent to Chile, to become vice-president and general manager for the Tofo iron mines there. Later, he returned to Cuba as vice-president and general manager of the Bethlehem-Cuba Mines Co., remaining there until 1928, when he was recalled to Bethlehem. He was made general manager of ore properties in 1939.

RUSSELL E. REILLY (Member 1945), manager of the Wyodak Coal and Mfg. Co., Gillette, Wyo., is dead. Mr. Reilly had been with the Company since 1941, and prior to that had spent twelve years in various positions with the Homestake Mining Co., ending there as head of the water and property department. A graduate of South Dakota's State Normal School, Mr. Reilly spent his first fifteen years with Homestake, and, from 1923 to 1929 was in charge of Cerro de Pasco's engineering office in Peru.

CHARD O. SANFORD (Member 1917), consulting mining engineer of Washington, D. C., died on Jan. 31 at the age of 66. In addition to his consulting practice, Mr. Sanford had been a mining engineer with the Bureau of Mines, the RFC, and the Premium Price Plan for metals from 1942 to 1947. Born in Iowa in 1884, Mr. Sanford attended the Universities of Washington, California, and Arizona, beginning his career as an assayer with the Skidoo Mines Co. in Inyo, Calif. In 1914 he was superintendent of the Antequera Tin Mine in Pazna, Bolivia, and, fourteen years later, held the same position with the Tom Reed mine in Oatman, Ariz. During World War I Mr. Sanford was a First Lieutenant with the Corps of Engineers. In 1938 he was Secretary of the Los Angeles Section, AIME.

GEORGE L. SMITH (Member 1945) is dead. Mr. Smith had spent his whole professional career with the Rochester and Pittsburg Coal Co., Indiana, Pa. He joined the company as a laborer a year after graduation from the Clarkson College of Technology in 1917, and through the years rose to the position of operating vice-president, which job he held at the time of his death.

PHILIP S. SMITH (Member 1918), leading government geologist, and a prolific writer in his field, died on May 10 at the age of 71. Mr. Smith had retired in 1946, but had since then been actively

engaged in private exploration work, chiefly in Alaska. He had three degrees, A.B., A.M., and Ph.D., from Harvard University. After receiving his A.B. in 1899, he joined the U. S. Geological Survey as a geologic aid. Two years later he was an instructor in geology and mining at Harvard, this association lasting for four years. Returning to the USGS, he began work on Alaskan explorations, and by 1925 he was named chief Alaskan geologist, continuing as such until his retirement three years ago. During that time he made numerous special investigations in the areal, physiographic, and economic geology of Alaska. One of the results of his work was the total of over 100 reports, published by the USGS, and in technical journals and publications of scientific societies.

Mr. Smith was a member of over seventeen professional organizations, including the Washington Academy of Sciences, the Society of Economic Geologists, the American Geophysical Union, and the American Polar Society.

WALTER STALDER (Member 1915), consulting petroleum geologist in San Francisco, died on May 27 at the age of 67. Mr. Stalder, who had been in consulting work since 1915, held B.S. and M.S. degrees from the University of California, the latter having been granted in 1907. Before entering private practice he had been in charge of property evaluation for the Union Oil Co. of California, and worked with M. L. Requa; the San Francisco Exploration Co.; and the Nevada Petroleum Co. Early in his career he developed the Decrease Curve method of estimating oil reserves, and later, in 1933, brought in the Sutter Buttes gas field in California. Mr. Stalder was the author of numerous articles on California oil geology which appeared in California state bulletins, professional magazines, and newspapers.

Proposed for Membership

Total AIME membership on July 31, 1949, was 15,844; in addition 4431 Student Associates were enrolled.

ADMISSIONS COMMITTEE

James L. Head, Chairman; Albert J. Phillips, Vice-Chairman; George B. Corless, T. B. Counselman, Ivan A. Given, George C. Heikes, Richard D. Mollison, and Philip D. Wilson.

Institute members are urged to review this list as soon as the issue is received and immediately to wire the Secretary's office, night message collect, if objection is offered to the admission of any applicant. Details of the objection should follow by air mail. The Institute desires to extend its privileges to every person to whom it can be of service but does not desire to admit persons unless they are qualified.

In the following list C/S means change of status; R, reinstatement; M, Member; J, Junior Member; AM, Associate Member; S, Student Associate; F, Junior Foreign Affiliate.

ALABAMA

Sheffield—TIEMANN, THEODORE DONALD. (M). Research engineer, Reynolds Metals Co.
University—BATOR, GEORGE THOMAS. (C/S—J-M). Associate professor of mining, University of Alabama.

ARIZONA

Ajo—RUSK, ALBERT T. (C/S—J-M). Mining engineer, New Cornelia branch, Phelps Dodge Corp.
Globe—MESSER, BEN GRANT. (C/S—J-M). Chief mine engineer, Miami Copper Co.
Inspiration—HAMBURGER, RICHARD. (C/S—J-M). Junior engineer, Inspiration Consolidated Copper Co.

CALIFORNIA

Arcadia—MAYHEW, ELDON JAY. (C/S—J-M). Operations manager, Building Products Div., Great Lakes Carbon Co.
Bakersfield—DORWART, GEORGE MARTIN. (C/S—J-M). Production foreman, Union Oil Co. of California.
Betteravia—GALLOWAY, TORRENCE DELOSS. (C/S—J-M). Research engineer, Union Sugar Co.
Darwin—TOGNONI, HALE, CHRISTOPHER. (C/S—S-J). Stope geologist and sampler, Anaconda Copper Mining Co.
Long Beach—ENSLEY, CHARLES, EARL. (C/S J-M). Development engineer, Southern Division, Richfield Oil Corp.; STONE, REID TOLAN. (C/S—S-J). Assistant field engineer, Axelson Manufacturing Co.; THORLEY, THOMAS J. (C/S—J-M). Senior harbor engineer, Port of Long Beach, Calif.
Los Angeles—BUTLER, WALLACE PIERCE. (C/S—J-M). President, Butler Ore Co.; MEYER, GENE. (C/S—J-M). Mill superintendent, Cie. Aramayo de Mines en Bolivie.
Oakland—OAKESHOTT, GORDON BLAISDELL. (M). Associate geologist, California Division of Mines.
Palo Alto—HURST, GEORGE PATERSON. (AM). Sales engineer, Bethlehem Steel Co., San Francisco Yard.
Riverside—MILLS, EUGENE ARTHUR. (C/S—J-M). Mining engineer in charge, Oliver Iron Mining Co. of Venezuela.
Sacramento—CRAIG, ROBERT HITCHCOCK. (C/S—J-M). Civil engineer, Corps of Engineers.
San Francisco—PRIMM, HERBERT ENGLAND. (M). Sales representative, Harbison-Walker Refractories Co.; RAWLINGS, STUART LAMAR, JR. (M). Vice-president and director, Standard Cyaniding Co. Director, San Luis Mining Co.
San Mateo—COULTER, RONALD SCOTT. (M). Combustion engineer, Pacific Coast operations, Bethlehem Pacific Coast Steel Corp.
Seal Beach—WALKER, ROBERT CARLTON. (C/S—S-J). Junior engineer, General Petroleum Co.
Whittier—ARTHUR, MILAN G. (C/S—J-M). Division production engineer, Union Oil Company of California.

COLORADO

Denver—NORMAN, TELFER E. (C/S—J-M). Metallurgical engineer, Climax Molybdenum Co.; RIDDLE, JOHN ALDEN. (C/S—S-J). Engineer trainee, Oliver Iron Mining Co.; WILSON, MALCOLM E. (C/S—J-M). Assistant to manager, wire products sales, Colorado Fuel & Iron Corp.
Gilman—SKINNER, JOHN PERKINS. (C/S—J-M). Assistant mine foreman, New Jersey Zinc Co.
Golden—CARPENTER, ROBERT H. (C/S—J-M). Assistant professor, Colorado School of Mines; consultant, New York & Honduras Rosario Mining Co.; ROBERTS, FRANK CULMER. (C/S—J-M). Design engineer in charge of Golden office, Climax Molybdenum Co.
Grand Junction—HALL, ROBERT B. (C/S—J-M). Geologist, Mineral deposits branch, U. S. Geological Survey.
Leadville—GUNELSON, ADOLPH GERHARD. (R, C/S—J-M). Chief mine engineer, Resurrection Mining Co.
Ouray—UNGER, RICHARD WILSON. (C/S—J-M). Mill superintendent, Idarado Mining Co.
Rifle—WRIGHT, FREDERICK DUNSTAN. (C/S—J-M). Unit chief of mining investigations unit, U. S. Bureau of Mines.

CONNECTICUT

New Haven—KOLB, THOMAS THORNTON. (C/S—J-M). General superintendent, A. N. Farnham, Inc.

DISTRICT OF COLUMBIA

Washington—FICK, NATHANIEL CROW. (C/S—J-M). Metallurgist and deputy executive director of Committee on Basic Physical Sciences, Dept. of National Defense.

IDAHO

Burke—FOLWELL, WILLIAM THOMAS. (C/S—J-M). Mining engineer, Hecla Mining Co.
Patterson—MECIA, JOSEPH ANTHONY. (C/S—J-M). Manager, Ima Mine, Bradley Mining Co.

ILLINOIS

Chicago—MANNAS, WILLIAM JOSEPH. (C/S—S-J). Petroleum engineer, The Pure Oil Co.; NICKEL, MELVIN E. (C/S—J-M). Assistant superintendent, open hearths, Wisconsin Steel Works, International Harvester Co.; WOODS, HENRY COCHRANE. (M). Chairman of board and vice-president, Sahara Coal Co.
Peoria—ALBERS, FRANCIS CLINTON. (C/S—J-M). Staff metallurgist, Caterpillar Tractor Co.; BESS-

LER, DELMAR RUSSELL. (M). Operating metallurgist, Keystone Steel & Wire Co.; REYER, EDWARD HARRY. (M). Open hearth superintendent, Keystone Steel & Wire Co.

INDIANA

East Chicago—DOAN, DONALD JAY. (C/S—J-M). Research metallurgist, Eagle-Picher Co.; RASSENFOSS, JOHN ALBERT. (C/S—J-M). Research metallurgist, American Steel Foundries.

West Lafayette—TAYLOR, WILLIAM EDWIN. (C/S—S-J). Research fellow, Purdue University.

KANSAS

Hugoton—FLOOD, WILLIAM HENRY, JR. (C/S—J-M). Field superintendent, Republic Natural Gas Co.

KENTUCKY

Wheelwright—BANKS, RALPH. (C/S—S-J). Safety inspector, Inland Steel Co.

LOUISIANA

New Orleans—SIMMONS, FRED E., JR. (C/S—J-M). Petroleum engineer, Louisiana Land & Exploration Co.

MASSACHUSETTS

Cambridge—GRANT, NICHOLAS JOHN. (C/S—J-M). Associate professor of metallurgy, Massachusetts Institute of Technology.

Southbridge—STREETER, THOMAS WINTHROP, JR. (C/S—S-J). Management trainee, American Optical Co.

MICHIGAN

Detroit—SPENCER, ANDREW R. (C/S—S-J). Sales engineer, Steel Sales Corp.

East Lansing—McGRADY, DENTON DELBERT. (C/S—J-M). Assistant professor of metallurgical engineering, Michigan State College.

Houghton—WALLACE, ROBERT RUNDLE. (C/S—S-AM). Junior mining engineer, Oliver Iron Mining Co.

Midland—SAUNDERS, WILLIAM PUTNAM. (J). Research and development engineer, Dow Chemical Co.

MINNESOTA

Duluth—THORPE, DEAN FRANKLIN. (C/S—S-J). Assistant concentration engineer, Oliver Iron Mining Co.

Hibbing—HARRISON, HUGH HOWARD. (C/S—S-J). General manager, Pacific Isle Mining Co.

Nashwauk—LIESKE, EARL FREDERICK. (J). Mill draftsman, Design Dept., Cleveland-Cliffs Iron Co.

MONTANA

Butte—JUDD, KENNETH MORTON. (C/S—S-J).

Libby—GALE, GEORGE DOUGLAS. (C/S—J-M). Mineral dressing engineer, Zonolite Co.

MISSISSIPPI

Laurel—LUBY, MICHAEL ANDREW. (J). Engineer trainee, Gulf Refining Co.

MISSOURI

Rolla—KENWORTHY, HEINE. (C/S—J-M). Metallurgist, U. S. Bureau of Mines.

St. Louis—BRUNE, ARTHUR WILLIAM. (C/S—J-M). Instructor in civil engineering, Washington Univ.; SPHAR, CURTIS WILLIAM. (C/S—S-J). Mineral Technologist, Missouri Pacific Lines.

NEW JERSEY

Mahwah—FLINN, RICHARD ALOYSIUS. (C/S—J-M). Section head, American Brake Shoe Co.

Maplewood—NEFF, CHARLES HAROLD. (M). Geologist, Gulf Oil Co.

Metuchen—QUADT, RAYMOND A. (C/S—J-M). Director of aluminum developments, American Smelting & Refining Co.

Morristown—GETZ, ALBERT J. (C/S—J-M). Plant engineer, Richard Ore Co.

Summit—WILLIAMS, RAYMOND T. (M). Design engineer, Anaconda Copper Mining Co.

NEW MEXICO

Carlsbad—GORDON, JOHN DAVIDSON, JR. (C/S—J-AM). Efficiency engineer, International Minerals & Chemical Corp.

Hanover—BLAKEMORE, PAGE BLANTON. (M). Mine superintendent, Peru Mining Co.; GALASSINI, MARIO. (M). Mine foreman, Peru Mining Co.; JEROME, STANLEY EVERETT. (R, C/S—J-M). Assistant to general superintendent, The New Jersey Zinc Exploration Co., S. W. Dept.

Silver City—VEEDER ARTHUR KIMBALL. (C/S—J-M). Manager and chemist, New Mexico Minerals Laboratory.

NEW YORK

Brooklyn—HILL, KENNETH EVAN. (C/S—J-M). Petroleum engineer, Chase National Bank.

De Grasse—WINSLOW, KENELM CRAWFORD. (C/S—S-J). Engineer, Hanna Coal & Ore Corp.

New York—FRANK, THOMAS W. (C/S—J-M). Consultant, Kenmore Metals Corp.; FRITZ, GLENN H. (C/S—J-M). Representative, export division, Joy Manufacturing Co.; HARMON, ROBERT B. (C/S—S-J). Partner, Harmon Lichtenstein & Co. (representative of Societe de la Vielle Montagne.); WRIGHT, MYRON ARNOLD. (C/S—J-M). Executive assistant, Standard Oil Co. (N. J.).

Scarsdale—READ, THOMAS ALBERT. (C/S—J-M). Associate professor of metallurgy, Columbia Univ.

Syracuse—HODAPP, WALTER LEONARD. (C/S—J-AM). Metallurgist, Crucible Steel Co. of America.

OHIO

Cleveland—FROST, BENJAMIN BURT. (C/S—J-M). Sales engineer, Arthur G. McKee & Co.

Elyria—GOUDVIS, THEODORE L. (C/S—J-M). President, Concrete Masonry Corp.

Warren—TOTTEN, PAUL RICHARD. (C/S—S-AM). Plant metallurgist, Thomas Steel Co.

OKLAHOMA

Duncan—KILGORE, JAMES GROVER. (M). Sales manager, Halliburton Oil Well Cementing Co.

Tulsa—HEMPHILL, JOHN WILBORN. (M). District engineer, Sinclair Oil & Gas Co.; INGRAM, CHARLES CLARK. (C/S—J-M). Engineer, Oklahoma Natural Gas Co.; KRIEGEL, MONROE W. (C/S—J-M). Research group leader, The Carter Oil Co.; SINSHEIMER, WARREN A., JR. (C/S—S-J). Petroleum engineer, Raymond F. Kravis.

OREGON

Coos Bay—SAMUELSON, RODNEY LEE. (C/S—S-J). Assistant to general superintendent, head draftsman, Coast Pacific Lumber Co.

PENNSYLVANIA

Aliquippa—EDWARDS, ROBERT EUGENE. (M). Assistant to open hearth and Bessemer superintendent, Jones & Laughlin Steel Corp.

Bethlehem—MANCKE, EDGAR B. (C/S—J-M). Engineer, Research Dept., Bethlehem Steel Co.

Bradford—VAUGHN, JOSEPH CHARLES. (C/S—S-J). Petroleum production engineer, Quaker State Oil Refining Corp.

Indiana—GRAFF, PAUL WILBUR. (C/S—S-M). President, Westmoreland Mining Co.

Lansford—GILBERT, JOSEPH C. (R, C/S—AM-M). Engineer-in-charge, Hazleton Field Station, U. S. Bureau of Mines.

Lebanon—HORST, RUSSEL JOSEPH. (J). Metallurgist, Bethlehem Steel Co.

Narberth—VAUGHAN, WARNER GLEASON. (M). Partner, Warner Vaughan Co.

New Kensington—FITZGERALD, ROBERT DALE. (C/S—S-J). Assistant metallographer, Aluminum Company of America.

Philadelphia—DALLAS, GEORGE MIFFLIN. (AM). Vice-President, Reading Briquet Co., American Briquet Co. & Ecco Manufacturing Co.

Pittsburgh—SPARR, WILLIAM HENRY. (C/S—J-M). Metallurgist, The International Nickel Co., Inc.

Pottsville—JONES, JOHN EDWARD. (J). Colliery engineer, Otto Colliery Co.

Scranton—DONNE, JOHN JENKIN. (M). Division mining engineer, Glen Alden Coal Co.

SOUTH DAKOTA

Lead—HOFFMAN, FRANCIS GERALD. (C/S—S-M). Mine surveyor, Homestake Mining Co.

TEXAS

Abilene — BRANTLY, MIMS McGEHEE. (J). Drilling engineer, Drilling & Exploration Co., Inc.; BRYSON, FRED EMERSON. (C/S—S-J). West Texas, New Mexico & Colorado district engineering manager, insurance co. inspector, Houston Fire & Casualty Insurance Co. & Companion Cos.; WILSON, HERBERT CLAY (C/S—J-M). Production superintendent, Geochemical Surveys.

Beaumont — MONTAGUE, KENNETH ELWIN. (C/S—J-M). Reservoir engineer, Sun Oil Co.; TUCKER, CHARLES WILLIAM. (R, C/S—S-J). Junior petroleum engineer, Stanolind Oil & Gas Co.

Corpus Christi—GIBSON, ROBERT L. (M). Division reservoir engineer, Shell Oil Co., Inc.; PIERCE, HAROLD FREDERICK. (R, C/S—S-M). Exploitation engineer, Corpus Christi Division, Shell Oil Co., Inc.; RYLANDS, ALBERT THOMAS. (C/S—J-M). Division production manager, Shell Oil Co., Inc.; WATKINS, OWEN MILTON, JR. (C/S—J-M). Production engineer, Pan American Production Co.

Fairbanks — SINEX, BRADFORD JAY. (C/S—J-M). District engineer, Amerada Petroleum Corp.

Falfurrias—CABINISS, BERT ADRON. (M). District manager, Sperry-Sun Well Surveying Co.

Fort Worth — DAGGETT, WILLIS KENNETH. (M). Sales manager, Welex Jet Services, Inc.

Houston — GLANVILLE, JAMES WILLIAM. (C/S—S-J). Research engineer, Humble Oil & Refining Co.; HOWARD, LEWIS BENTON. (C/S—J-M). Petroleum engineer, American Republics Corp.; NEWSONIE, JOEL ARTHUR, JR. (C/S—J-M). Vice-President, Parks Engineering Co.; WEATHERLY, JUSTIN EUGENE, JR. (C/S—S-J). Petroleum engineer trainee, Gulf Oil Corp.; WINSAUER, WELDON OTTO. (J). Assistant research engineer, Production Research Dept., Humble Oil & Refining Co.

Kilgore—ECKART, ROBERT RONDO, JR. (C/S—J-M). Division production geologist, Shell Oil Co., Inc.

Midland—BONNELL, ROBERT ALFRED, JR. (M). Engineer, Sinclair Oil & Gas Co.; FITTING, ROBERT DANCY. (C/S—J-M). Member of firm, Fitting, Fitting & Jones.; RANDERSON, LUTHER WINN. (C/S—J-M). Petroleum engineer, Magnolia Petroleum Co.; SIMPSON, JULIAN MOORE. (J) Junior engineer, Sinclair Oil & Gas Co.

San Antonio — PARKS, ROBERT HALL. (C/S—S-J). Petroleum engineer, Sunray Oil Corp.; RENFRO, HEATH. (R, C/S—S-M). Production Supt., Ralph E. Fair, Inc.; TOWER, JOHN RUSSELL. (AM). Petroleum engineer, Seeligson Engineering Committee.

Texas City—REIKIE, MATTHEW KER THOMSON. (M). Superintendent of research, Tin Processing Corp.

Wichita Falls — GOULDY, ROLAND. (C/S—J-M). Petroleum engineer, Bridwell Oil Co.

UTAH

Eureka — FITCH, CECIL ALOYSIUS, JR. (C/S—J-M). Assistant general manager, Chief Consolidated Mining Co.

Midvale — TONNESEN, ROBERT SVANE. (C/S—S-J). Mucker, U. S. Smelting & Refining Co.

WASHINGTON

Olympia—RECTOR, MICHAEL ROBERT. (C/S—S-J). Field geologist, Union Oil Co. of California.

Spokane—KAISER, EDWARD PECK. (C/S—J-M). Regional geologist, New Jersey Zinc Co.

WEST VIRGINIA

Holden—NORTHCOTT, ELLIOTT, II. (J). Preparation engineer, Island Creek Coal Co.

Huntington — RUDNICKI, JOHN WALTER FRANCIS. (C/S—S-J). Field engineer, The C. & O. Railway Co.

WISCONSIN

Cudahy — AGUIRRE, LUIS ENRIQUE. (M). Erection engineer, Allis-Chalmers Mfg. Co.

WYOMING

Laramie—FEARN, LYMAN. (M). State inspector of mines, State of Wyoming.

Rock Springs—FISHER, SYLVESTER JAMES. (C/S—S-J). Petroleum engineer, Mountain Fuel Supply Co.

ALBERTA

Calgary — KELLER, ALFRED EMIL. (C/S—J-M). Assistant to manager, Texaco Exploration Co.

BRITISH COLUMBIA

Britannia Beach — CHLUMECKY, NICHOLAS. (AM). Miner, Brittannia Mining & Smelting Co., Ltd.; McKICHAN, JOHN DOUGLAS. (C/S—J-M). Ventilation engineer, Britannia Mining & Smelting Co., Ltd.; ROPER, EDWARD CECIL. (C/S—J-M). Manager, Britannia Mining & Smelting Co., Ltd.

ONTARIO

Black Donald Mines — EDWARD, BRUCE GARFIELD. (C/S—J-M). Manager, Black Donald Graphite Division, Frobisher, Ltd.

Ottawa—HAYSLIP, GORDON OSCAR. (C/S—J-M). Mineral dressing engineer, Bureau of Mines.

DURANGO

Tayoltita—WOODS, ROBERT GRAYSON. (C/S—J-M). Mill superintendent, San Luis Mining Co.

GUERRERO

Mexcala—SMITH, WALTER ALTON. (M). Mine superintendent, Cia. Minera del Mexcala.

HIDALGO

Taxco — COOPER, JAMES RENRICK. (C/S—J-M). Metallurgist, American Smelting & Refining Co.

SONORA

Cananea—VELASCO, J. RUBEN. (C/S—J-M). Field geologist, Anaconda Copper Mining Co.

BOLIVIA

Oruro—ALBERTSON, FLOYD ELI. (C/S—J-M). Mill superintendent, Cia. de Mines de Colquiri.

BRAZIL

Rio de Janeiro—DEARAUJO, OLVEIRA, GABRIEL MAURO. (C/S—J-M). Mining engineer, Dept. Nacional de Producao Mineral.

COLOMBIA

Bogota—COSTER, WILLEM ARNOLD. (C/S—J-M). Consulting engineer, self. HESS, LORAIN. EMMETT. (C/S—J-M). Chief petroleum engineer, Socony-Vacuum Oil Company of Colombia.

ECUADOR

Guayaquil — WILLIAMS, CLARENCE THOMAS. (C/S—J-M). Engineer-foreman in charge of Mines Nuevas operation, Calera Exploration Co.

PERU

La Oroya—LACY, WILLARD CARLETON. (C/S—J-M). Petrologist, Cerro de Pasco Copper Corp.

VENEZUELA

Cumarebo — BOSSERT, WARREN HARRIS. (J). Petroleum engineer, Creole Petroleum Corp.

ENGLAND

Yorkshire — FRANCIS, SYDNEY. (M). Chief metallurgist and managing director, Brontalloy, Ltd.

GERMANY

Stuttgart — SCHRAMM, JACOB. (M). Chief metallurgist, Metall-Guss and Presswerk Heinrich Diehl. Vide; Univ. Teacher, Technische Hochschule.

LUXEMBURG

Luxemburg—SCHMIT, RENE. (M). Superintendent, Aciéries Réunies de Burbach-Eich-Dudelange.

SYRIA

Aleppo—TCHALABI, MOHAMMED TAHER. (J).

INDIA

Bokaro—SHOME, MAKHAN LALL. (M). Superintendent of Collieries, Government of India.

PHILIPPINE ISLANDS

Manila — THORMEYER, WALTER RICHARD. (C/S—J-M). Sales engineer, mining dept., Earnshaws Docks & Honolulu Iron Works, Manila.

STUDENT ASSOCIATES

Elected August 17, 1949

Thomas B. Budinger....Penn State
Noel F. Herbst.....Melbourne Univ.
Raghunath C. Deshpande......RPI
James R. Easterday...Wayne Univ.
Bernhardt H. Petersen
.... Mich.Min. & Tech.
Earl G. Thurman.......Univ. Okla.

Field Trips

ALL day Thursday, September 29 will be devoted to field trips, and Members attending the Mid-Year Meeting can take their choice from among the six outlined here.

1. Battelle Memorial Institute and Ohio State University. Battelle is the largest independent industrial research foundation in the nation, with an international reputation for research in metallurgy,

Flotation Research at Battelle.

fuels, ceramics, corrosion technology and graphic arts. It has gained distinction in fields ranging from industrial physics to engineering economics. At Ohio State, visitors will see a special exhibit by the State's Archaeological and Historical Society, a demonstration of the fire wall tests now being conducted, and the new cyclotron.

2. Hanna Coal Co., Cadiz, Ohio. Coal men and open-pit operators will enjoy this trip through the Company's underground coal mine, as well as the completely modernized coal laundry and coal cleaning plant, where it is now possible to dry coal to within 2 percent of the surface moisture. But the day's feature will be the operation of the world's largest open pit mining shovel, the giant which scoops up 49 cubic yards at one time.

3. Jeffrey Manufacturing Co. and Battelle Memorial Institute. The big 50-acre Jeffrey plant where emphasis is placed on the mechanized aspects of drilling, cutting, loading, conveying, transporting, screening, beneficiation, sizing and ventilation will provide the first half of the trip. Visitors will see mining material handling and processing from raw product to finished mining machine. At Battelle, the accent will be on the research being carried out by the Bituminous Coal Research Association there.

4. Lustron Corp. and Owens-Corning Fiberglas Co. Members who are bothered by the housing shortage will enjoy the Lustron plant, where 100 steel and enamel dwellings are mass-produced each day. At the Owens-Corning plant in Newark, Ohio, white fleecy blankets of Fiberglas move along on conveyor belts to their ultimate destination as thermal insulation materials in domestic appliances, industrial equipment, and all types of transportation equipment.

5. Pure Oil Refinery and Permanente Metals Corp. This is designed to satisfy both metallurgists and Petroleum Branch Members. Many unusual operations will be available for inspection at the Pure Oil refinery, and the Permanente tour will embrace the Company's operations in working high purity aluminum pig into transmission cable wires. Four dollars for this trip.

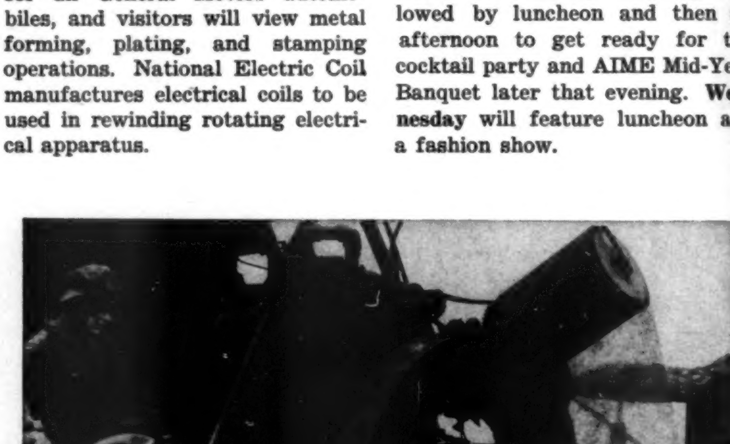
6. Turnstead Division, General Motors Corp.. and National Electric Coil Co. Plant hardware is produced at the Turnstead Plant for all General Motors automobiles, and visitors will view metal forming, plating, and stamping operations. National Electric Coil manufactures electrical coils to be used in rewinding rotating electrical apparatus.

The Ladies

Mrs. AIME can relax at the Mid-Year Meeting, and enjoy a round of informal fun. There'll be no long-dress affairs emphasizing formality, including the Mid-Year Banquet at the Neil House.

The Proceedings will start with the registration on **Monday** morning, Sept. 26, and then, at noon, the All-Institute luncheon will begin. That afternoon, the ladies will go on a sightseeing tour of Columbus, through the Governor's mansion, Battelle Memorial Institute, Capital University, Ohio State University, and yes, even the Ohio Penitentiary.

Another inspection trip is scheduled for **Tuesday** morning, followed by luncheon and then all afternoon to get ready for the cocktail party and AIME Mid-Year Banquet later that evening. **Wednesday** will feature luncheon and a fashion show.



Wrapping underground pipe with Fiberglas.

Registration will begin Sunday, Sept. 25, at the Neil House, and continue through Monday morning. Members, $3, non-members, $5. Members and non-members will be distinguished from one another by different colored registration badges. This will give members an opportunity to extend courtesies to non-members.

Social events: Banquets — AIME Mid-Year Banquet, Wednesday evening. Preceded by a cocktail party. Tickets, $6.50. Annual Banquet, Southern Ohio Section, National Open Hearth Committee, AIME, on Friday evening. Tickets, $6. **Others** — Dinner-in-the-Sky, Wednesday evening. Scotch Breakfast, Minerals Beneficiation Division, Tuesday morning.

Luncheons: Monday, All-Institute Luncheon. $3.50. **Tuesday,** AIME Board of Directors; Extractive Metallurgy Division, ($3.50); Executive Committee, Coal Division ($3.50). **Wednesday,** Minerals Beneficiation Division ($3.50); Coal Division ($3.50); and Industrial Minerals Division ($3.50).

Meetings: Missouri School of Mines Alumni will hold a party on Monday evening, Sept. 26. **The Petroleum Branch** will meet on Monday, Tuesday and Wednesday. See the **Journal of Petroleum Technology** for details. **The Mineral Industry Education Division** will meet on Sunday afternoon at the Neil House.

Hugo Johnson

General Chairman, AIME Mid-Year Meeting

Technical Sessions

Mining Geology

Tuesday Afternoon

Technical Session.

Underwater Seismic Investigations for Civil Engineering Studies. By Robert E. Barnett, Geologist, Corps of Engineers, Ohio River Division Laboratories.

Trace-element Studies, Santa Rita, New Mexico. By Paul F. Kerr, Prof., Mineralogy, Columbia University, and Donald L. Graf, Illinois Geological Survey.

Tin Deposit of Monserrat, Bolivia. By Russell Gibson, Assoc. Prof., Geol., Harvard Univ., and F. S. Turneaure, Assoc. Prof., Geol., Univ. Michigan.

Minerals Beneficiation Division

Sunday Afternoon

Informal business session. S. J. Swainson, presiding.

Monday Afternoon

Technical Session, E. H. Rose and Harlowe Hardinge, Chairmen. Junior Ball Room, Neil House.

Unit Process of Crushing and Grinding

Effects of Rod Mill Feed Size Reduction. By John J. Strohl, Mill Supt., and Harry J. Schwellenbach, Mill Operator, National Lead Co.

Use of Spiral Classifiers as Ball Mill Feeders. By T. C. King, Eagle Picher Co.

Relative Wear Rates of Various Diameter Grinding Balls. By D. E. Norquist, Sheffield Steel Co.

Grinding Progress at Tennessee Copper. By J. F. Myers, Mill Supt., and F. M. Lewis, Asst. Mill Supt., Tennessee Copper and Chemical Co., Copperhill, Tenn.

Tuesday Morning

Scotch breakfast.

Technical Session, E. H. Crabtree, Jr., Chairman. Junior Ball Room, Neil House.

Unit Process of Concentration

The Flotation of Copper-zinc Sulphide Minerals of the Prince Leopold Mine. By Charles Piedboeuf.

Flotation of Chalcocite. By S. B. Tuwiner and S. Korman, Dept. of Devel. and Research, Phelps Dodge Corp., Laurel Hill, N. Y.

The Frothability of Pine Oils. By S. C. Sun, Asst. Prof., Mineral Preparation, Penn. State Coll.

The Behavior of Mineral Particles in Electrostatic Separation. By S. C. Sun, J. D. Morgan, Jr., National Security Resources Board, and R. F. Wesner, Engr., McNally Pittsburgh Mfg. Corp.

Tuesday Afternoon

Technical Session, Raymond E. Byler, Chairman.

Unit Process of Operating Control

An Electronic Tramp Iron Detector. By C. M. Marquardt, Mining Engineer and Geophysicist, Combined Metals Reduction Co.

Statistical Control Methods. By W. F. Keyes, Jr., Mineral Engr., and M. H. Dorenfeld, Mineral Engr.

Experiences with a Density Recording and Control Instrument for Heavy Media Separation. By J. J. Bean, Min. Dressing Engr., American Cyanamid Co.

Paper on pumping by Wm. B. Stephenson, The Allen Sherman Hoff Co.

Wednesday Morning

Technical Session, I. M. LeBaron, Chairman.

Symposium on Grinding
(titles later)

Wednesday Noon

Minerals Beneficiation Division—Business Luncheon. S. J. Swainson, Division Chairman, presiding.

Wednesday Afternoon

"Clean-up" Session, Donald W. Scott, presiding.

General Discussion of all papers.

Extractive Metallurgy Division

Tuesday Morning

Technical Session.

Titanium Investigations: Research and Development Work on the Preparation of Titanium Chloride and Oxide from Titanium Mattes. By R. G. Knickerbocker, C. H. Gorski, H. Kenworthy and A. G. Starliper, Met. Div., U. S. Bureau of Mines, Rolla, Mo.

A Thermodynamic Investigation of the System Silver-silver Sulphide. By Terkel Rosenqvist, Institute for the Study of Metals, University of Chicago.

Industrial Minerals Division

Monday Afternoon

Building Materials; Groundwater.

Industrial Limestones of Indiana. By John B. Patton, Indiana Geological Survey.

Limestone in the Muskingum Valley. By C. H. Bowen, Ohio State University Experiment Station.

Raw Material Economics of the Ohio Cement Industry. By R. J. Anderson, Battelle Institute.

Occurrence of Groundwater near Lexington, Kentucky. By D. K. Hamilton, Univ. of Kentucky.

Our Nation's Building Stone. (Film.) By M. J. Morgan, Indiana Limestone Producers Ass'n.

Tuesday Morning

Mineral Deposits.

Silica Deposits of Arkansas. By W. B. Mather, Southwest Research Institute.

Kaolin in Texas. By F. K. Pence, University of Texas.

Mineral Resources of the Lone Star Steel Company. By A. B. Drescher, Lone Star Steel Co.

Geologic Exploration for Uranium in the Colorado Plateau Area. By Wallace G. Fetzer, Atomic Energy Commission.

Tuesday Afternoon

Preparation; New Products.

Problems of Preparation of Limestone Samples for Spectrographic Analysis. By Richard K. Leininger, Indiana Geological Survey.

Petalite—A New Commercial Mineral. By John D. Clarke, Foote Mineral Co.

Sand Deposits of Northern Ohio. By Wm. Smith, Ohio State Univ.

Producing Strong Light-weight Aggregate Using a Wide Variety of Clays. By G. A. Bole and K. B. Czarnecki, Ohio State University Experiment Station.

Refractory Clay Situation in Ohio and Kentucky. By J. O. Everhart, Ohio State University Experiment Station.

Wednesday Morning

Salt Deposits.

Salt Deposits of New York State. By John G. Broughton, New York State Science Service.

Salt in the Northern Appalachian Area. By John A. Ames, Baltimore and Ohio Railroad.

Geology of Michigan Salt Deposits. By Harry J. Hardenberg, Michigan Geol. Survey.

Salt Deposits of Kansas.

Wednesday Afternoon

Wednesday afternoon left open so members of Industrial Minerals Division may attend the Air Pollution session of the Coal Division, at 2 p. m.

Coal Division

Monday Afternoon

Student Forum—joint with all Divisions.

Panel: Moderator, C. E. Lawall, Chesapeake & Ohio Railway Co. A. R. Anderson, Mgr. of Sales, Mining Div., The Jeffrey Mfg. Co., Columbus. C. E. Bales, vice president, Ironton Fire Brick Co. M. D. Cooper, Mgr., Vocational Training, National Coal Association. Gerald C. Gambs, Mgr., Service Dept., Pittsburgh Consolidation Coal Co. James Hyslop, Exec. Vice Pres., Hanna Coal Co. L. F. Reinartz, vice president, Armco Steel Corp. D. T. Ring, vice president, The Preston Oil Company. Clyde E. Williams, director, Battelle Memorial Institute.

Tuesday Morning

Coal Geology and Synthetic Fuels.

Coal Reserves of Perry County, Ohio. By Norman K. Flint, Geological Survey of Ohio, Columbus, Ohio.

Research in Coal Geology. By Gilbert H. Cady, Illinois State Geological Survey, Urbana, Ill.

Preparation of Coals for Synthetic Liquid Fuels. By Wm. J. Crentz and J. D. Doherty, U. S. Bureau of Mines, Washington, D. C.

Discussions: Synthetic Liquid Fuel Studies in Ohio. By W. H. Smith, Geological Survey of Ohio, Columbus, and C. A. Bowen, Ohio State University, Columbus.

Tuesday Noon

Luncheon. Coal Division Executive Committee.

Tuesday Afternoon

Symposium on Continuous Mining.

The Analysis for a Continuous Mining Machine. By Gerald van Stroh, BCR Mining Development Committee, Huntington, W. Va.

The Colmol, A Continuous Mining Machine. By Clifford H. Snyder, Sunnyhill Coal Co., Pittsburgh.

The Continuous Miner. By W. B. Jamison, Jamison Coal & Coke Co., Greensburg, Pa.

Dosco Continuous Miner.

Wednesday Morning

Promises for A.C. Power Economies with New Mining Methods. By J. R. Guard, Rochester and Pittsburgh Coal Co., Indiana, Pa.

Symposium on Mine Roof Pinning: Latest Developments in Roof Bolting. By Edward Thomas, U. S. Bureau of Mines.

Paper by Lee Siniff, Consolidation Coal Co. (Ky.), Jenkins, Ky.

Mining Methods

Tuesday Morning

Technical Session.

Development Work with Trackless Equipment. By E. A. James, Asst. Gen. Mine Supt., Southeast Missouri, St. Joseph Lead Co.

Wrapping Pillars with Old Hoist Rope. By B. T. Wykoff, Mine Supt., St. Joseph Lead Co.

Stresses About Mine Openings. By Louis A. Panek, U. S. Bureau of Mines, College Park, Md.

Wednesday Morning

Technical Session.

A Classification and Application of Drill Jumbos. By O. J. Neslage and R. W. Jenkins, Joy Mfg. Co.

Pneumatic Sectional Steel vs. Diamond Core Drill Sampling in Brecciated Rock, Aspen, Colorado. By Paul T. Allsman, U. S. Bureau of Mines, Salt Lake City, Utah.

Development in the Use of Steel for Underground Support. By F. J. Haller, Supt., Mather Mine, The Cleveland-Cliffs Iron Co.

Concrete Slusher Drifts. By Joseph Bernhardt, Mine Supt., Mine No. 4, Bethlehem Steel Co.

Wednesday Noon

Coal Division Luncheon.

Wednesday Afternoon

Symposium on Air Pollution. Ballroom, Neil House.

Some of the Unknown Air Polluting Solids of Alleghany County. By T. C. Wurtz, County of Allegheny, Pittsburgh, Pa.

Air Pollution by Industrial Gases and Liquids. By L. C. McCabe, U. S. Bureau of Mines, Washington, D. C.

Discussions: W. C. L. Hemeon, Industrial Hygiene Foundation, Pittsburgh, Pa. Henry F. Hebley, Pittsburgh Consolidation Coal Co., Pittsburgh, Pa.

Mechanization at the Bureau of Mines Oil-shale Mine

By E. D. GARDNER* and E. M. SIPPRELLE,† Members AIME

The Synthetic Liquid Fuels Act (58 Stat., 190; 30 U.S.C. Sup., Secs. 321–325) was approved by Congress April 5, 1944; it directed the Bureau of Mines to build demonstration plants to produce synthetic liquid fuels from coal, oil shale, and agricultural products.

The most important oil-shale deposits in the United States are in the Green River formation of Colorado, Utah, and Wyoming. The oil shale of western Colorado generally is more amenable to exploitation, more persistent, and apparently richer than elsewhere in the Rocky Mountain Region. It occurs at the top of a high plateau surrounded by bold, nearly vertical escarpments 500 to 600 ft in height. The top 400 to 500 ft of these escarpments comprises an oil-shale measure that averages 15 gal of shale oil per ton; the bottom 70 to 100 ft of the measure, called the Mahogany Ledge, averages over 30 gal per ton. The full measure in a 1000-square-mile area is estimated to contain 300 billion barrels of shale oil;[1] the Mahogany Ledge is estimated to contain 100 billion barrels of oil. These estimates are based on numerous surface samples and on core-drill holes drilled by the Government and by private enterprise.

The oil-shale beds are undisturbed and lie nearly horizontal. The name "oil shale" is unfortunate, as the rock is a tough, strong marlstone. Organic matter named "kerogen" is a constituent of the rock.

The oil-shale demonstration mine is on Naval Oil-Shale Reserve No. 1; it is about 5½ miles by mountain road from the plant site, which, in turn, is 2 miles from U.S. Highway 6 and 10 miles west from Rifle, Colo. The highway parallels the Colorado River, the Denver and Rio Grande Western Railroad, and a 66,000-volt public-utility power line.

Early in the program it was realized that an oil-shale enterprise would have to be on a large scale to be commercial, and that unusually low mining costs would be necessary. The physical characteristics of the Mahogany Ledge and an overlying roof stone are unusually favorable both for large-scale operation and low mining costs. Quarry practices largely will be followed underground to mine the Mahogany Ledge. The aim has been toward complete mechanization of all mining operations.

A mining unit would comprise a square mile containing 100,000,000 tons of oil shale with allowance for mining losses. An investment of $1,000,000 would be $0.01 a ton; such an expenditure, therefore, could be made to save, say, $0.015 per ton daily operating cost.

A goal of a mining cost of $0.50 per ton was set up in 1945. Open-cut mining costs then were about $0.25 per ton of material handled; it was hoped that a cost double this amount could be obtained in mining the Mahogany Ledge. Costs of labor and supplies have increased since 1945 and so has the selling price of petroleum products.

To those unacquainted with the character of the Green River deposits, the name "shale" suggested high mining costs. Others assumed that coal-mining costs of $2 to $5 per ton would apply. To many, the expected mining costs appeared the principal handicap to the establishment of an oil-shale industry. The purpose of the Bureau of Mines is to demonstrate methods and to establish costs for mining the oil shale on a large scale. It is hoped this work will lead to the establishment of a large-scale, commercial oil-shale enterprise.

San Francisco Meeting, February 1949.

TP 2666 A. Discussion of this paper (2 copies) may be sent to *Transactions* AIME before Oct. 30, 1949. Manuscript received March 14, 1949.

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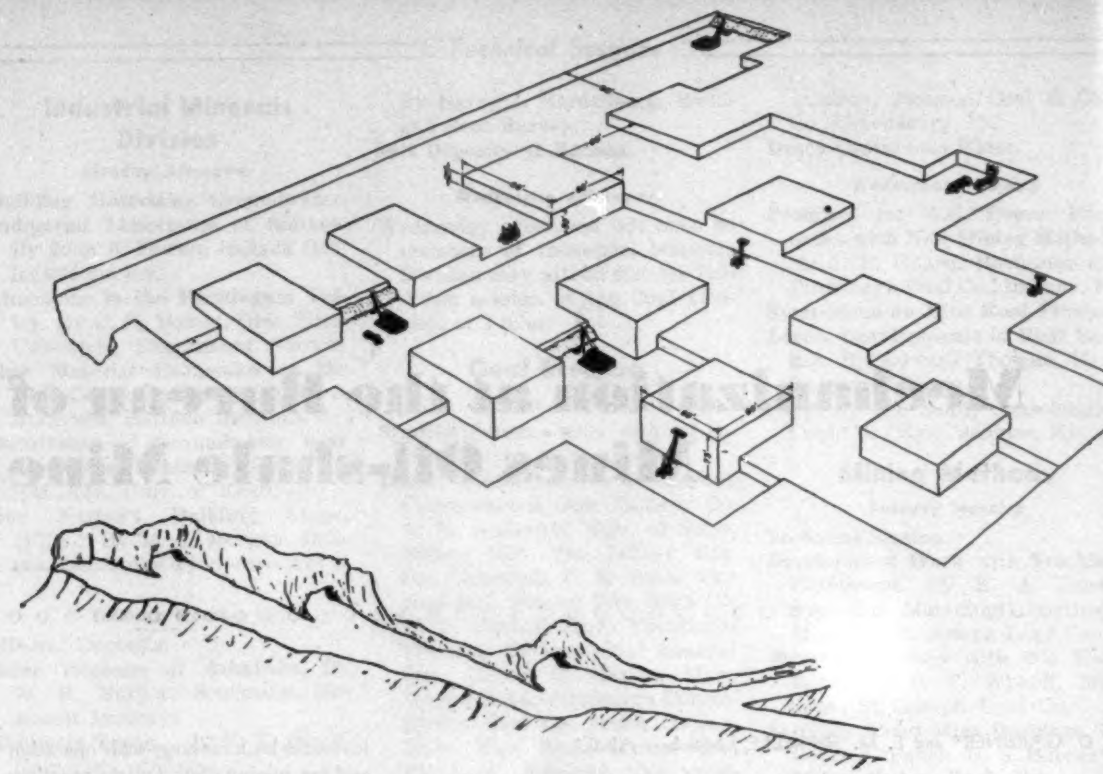

FIG 1—Underground quarry mine layout, oil-shale demonstration plant, Rifle, Colo.

Mining Methods

The first problem to be solved, obviously, was to determine how large openings could be maintained safely underground without artificial support. To this end, representative samples of the Mahogany Ledge and of the roof stone were tested at Columbia University and at the Bureau of Mines stations at College Park, Md., and at Pittsburgh, Pa.[2] The theoretical results indicated that the overlying formation could be supported by 60 ft square pillars spaced 60 ft apart, and that the roof stone would safely stand in the openings. A test room 50 by 100 ft was excavated under the roof stone in 1946 to obtain a practical check on the theoretical results. It was widened to 60 ft in May 1947, to 70 ft in August 1947, and to 80 ft in November 1948. During this period, daily sag measurements were taken; rock noises also were recorded through a system of geophones connected to a microseismic recorder. To date there has been no evidence that undue stresses have developed in the roof stone either in the test room or the mine workings. The danger of projecting the results beyond the workings is recognized. The quality of the roof stone, however, is so remarkably consistent that it is felt the data are reliable.

It was decided to mine the Mahogany Ledge by advancing three levels horizontally into the Mahogany Ledge. The advance heading is 27 ft, and each of the other two levels is 21½ ft high; the lower levels will follow the advance of the top level similar to benches in a quarry. Fig 1 illustrates the proposed mine layout. By having the advance level at the top, work on all three levels is under the good roof stone. Moreover, the roof and upper parts of the pillars are more accessible for initial scaling and inspection from the top level than from a lower one.

Breaking

The only major operation in the underground mine essentially different from quarry practice is drilling and blasting in the advance heading. Faces on this level have only one free face to which to break. Drill holes must be drilled more accurately to pattern, more holes are required, and more explosive is needed per ton broken than will be required on the lower benches, which will have two free faces. Moreover, drilling horizontal holes in a 27 by 60 ft face is much more difficult than drilling vertical down holes on a bench.

To date most of the effort at the oil-shale demonstration mine has been the development of equipment and procedures for drilling and blasting on the top level.

DRILLING

The initial drilling investigations were time studies of conventional drilling practices using standard 3 in. rock drills mounted on columns. The results obtained from these studies were startling; a miner and chuck tender were required for each machine, and the drill was actually drilling less than one-third of the work shift. The remainder of the time was spent in setting up, tearing down, changing drill steel, changing position of the drill on the arm and column, and other tasks.

Analysis of these data indicated that the drilling phase was a logical one with which to start mechanization. It was reasoned that if changing drill steel could be eliminated by the use of 10

to 15 ft drill rods and of 10 to 15 ft drill feed carriages, and if the setting up, dismantling, and changing of the drill position could be mechanized adequately, at least one man of the drilling crew per machine would not be needed. Drilling with long rods in a mechanized operation also would allow a greater actual drilling time per machine.

The first obstacle in the path of the program for the mechanization of drilling was that conventional detachable rock bits could drill only from 3 to 5 ft in oil shale without becoming dull. This, of course, required changing of bits or rods several times for each hole. To overcome this handicap, a research program was instigated to develop a hard-surfaced rock-drill bit that would drill at least 10 ft without becoming dull. As a result, a bit hard-surfaced with tungsten-carbide was developed, which consistently drills over 70 ft before it requires resharpening.[3]

Mechanizing the various drilling operations for drilling flat holes of a round in a 27 ft high by 60 ft wide face presented another problem. A solution for this was found in a new and efficient type of multiple-drill carriage (or jumbo) designed and built on contract (Fig 2). This unit has two horizontal platforms mounted on a framework at the rear of a diesel truck. Each platform contains two 4 in. percussion drills mounted on 11½ ft feed slides. The vertical inclinations of the feed slides are controlled by screws and ratchets. Air hoists are used for raising and lowering the platform; spur gear devices permit swinging the platforms to various horizontal angles. A water tank and air hose reel also are mounted on the truck. Only the 3-in. air hose has to be connected to the air supply preparatory to drilling. The four drills mounted on the carriage are operated by two men. By use of the multiple-drill carriage, two miners can drill a round with 10 ft steel in about 5 hr. Prior to the time the Bureau of Mines multiple-drill carriage was placed in operation, drilling on the top level was done with conventional wagon drills which required two men to a machine. Over 10 man-shifts were required to drill a 10 ft round with this equipment. Longer drill feed slides have been designed and are being built for the multiple-drill carriage. These slides will enable 15 ft holes to be drilled. It is expected that these longer rounds can still be drilled by two men in an 8 hr shift and will break 1500 tons.

FIG 2—Multiple drill carriage or jumbo for drilling advance heading of underground quarry.

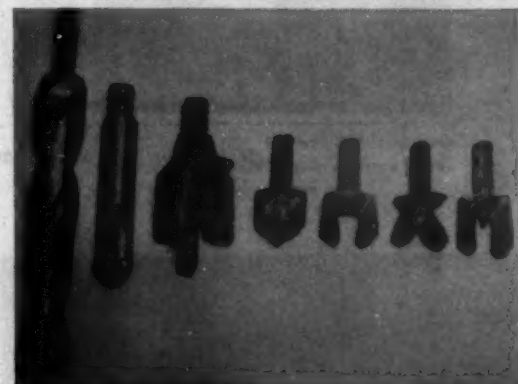

FIG 3—Experimental auger-type bits for drilling oil shale.
Left to right: 1⅞ in. carbon steel twist drill with hard-surfaced cutting edges; 1½ in. insert-type Cyclone masonry bit; 3½ in., 3-prong Kennametal insert bit with shop-made pilot; 2½ in., 2-prong Sulmet insert bit with shop-made pilot; 2¼ in., 2-prong standard Kennametal insert bit without pilot or core breaker; 2¼ in., 2-prong field insert bit; 1⅞ in., 2-prong Kennametal insert bit with core breaker.

Although breakage of the long drill rods because of fatigue appears about normal, the cost of steel per ton of oil shale mined is excessive. A research problem was set up to investigate the use of alloy drill steels and to find some method of treating used drill steel to relieve fatigue strains. Experiments using alloy drill steel have been discouraging, and no furnace long enough has been found in which to treat the drill steel. An encouraging result was noted while testing an Ingersoll-Rand type 2 insert bit. The life of the drill steel during this experiment was almost double that obtained with another hard-surfaced bit. The increased life is believed to be due to the fact that the insert bit maintained a sharper cutting edge throughout the life of the rod, thereby reducing the fatigue shock. At the time of writing, the bit had drilled 1680 ft in oil shale with no apparent damage or dulling.

Although the mechanized jumbo using percussion drills powered with compressed air may be considered adequate for the drilling phase of the top heading, it is not necessarily the best solution. A research program currently is being conducted at Rifle to develop a rotary drill and auger-type bits for drilling oil shale. The rotary drill has a number of advantages over the percussion drill:

1. The drilling rate is higher.
2. The breakage of drill rods would be considerably less.
3. Electric power could be substituted for more costly compressed air.
4. Deeper rounds could be drilled without loss of drilling speed.
5. The noise of percussion drills would be eliminated in the mine workings.

As in the case of percussion drilling, the selection and development of a bit is the primary problem. Numerous types of rotary drill bits with tungsten-carbide inserts are being tested. Some of these bits are shown in Fig 3. Nearly all of the bits pictured have satisfactorily drilled the higher grade oil-shale

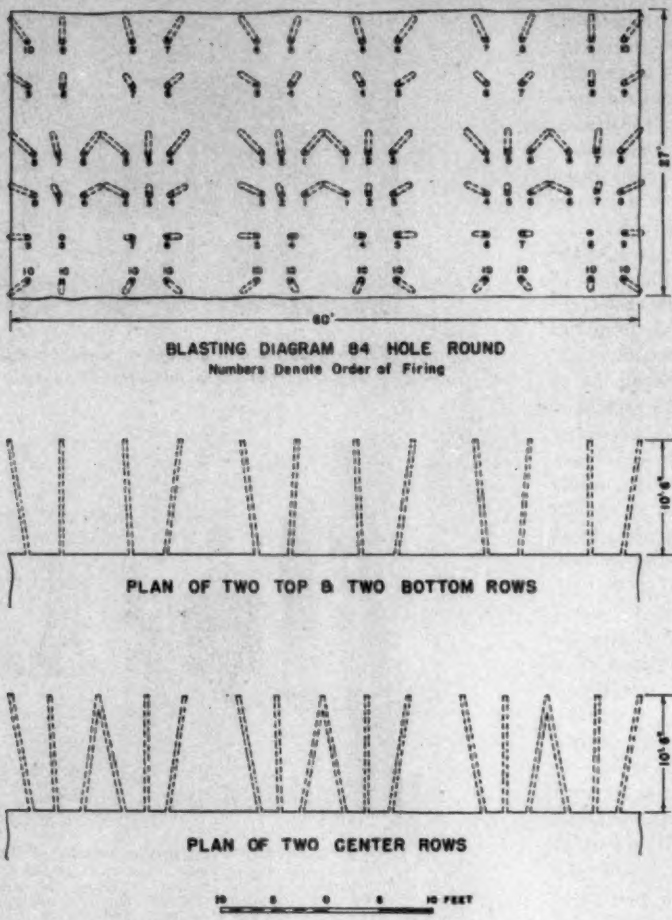

FIG 4—84 hole round using 3 V-cuts.

beds of the middle third of the Mahogany Ledge at a rate of 36 to 42 in. per minute actual drilling time. As the inserts either become dull or broken with 3 to 5 ft of drilling in the lower-grade oil shales of two-thirds of the Ledge, the bits cannot be considered adequate. One possible exception is the Cyclone masonry bit manufactured by the New England Carbide Tool Co. This bit, in the one test made up to the time of writing, drilled 70 ft into the lower-grade oil shale at a rate of 33.5 in. per minute before resharpening was necessary. A bit is desired that will have a life long enough to compensate for the higher cost of this type of bit; it also should have a drilling speed, with a rotary drill, at least double that ordinarily obtained with the percussion drills.

Many standard rounds for large headings, with variations, have been tried. The pattern found to be most successful to date in a 60 ft wide by 27 ft high heading is shown in Fig 4. The top holes bottom about 1 ft from the roof stone and break to an uncemented bedding plane at the roof stone. This round has a total of 84 holes averaging 10 ft in depth; it will break about 1000 tons of rock with a powder consumption of 0.56 lb per ton. It is drilled in three settings of the jumbo and is blasted in three series in a parallel. This round will be used as the basis for developing the best pattern for a 15 ft deep round that will be drilled when the new slides are installed on the multiple-drill carriage.

BLASTING

The cost of explosives probably will be the largest single item of expense in mining oil shale on a large scale. Considerable research, therefore, is justified to ascertain the grade and type of explosive that will give optimum results and to determine the best procedures to follow for a minimum overall breaking cost. The goal set up at the beginning of the project was not to exceed half a pound of explosive per ton of oil shale broken.

Early blasting experiments were made with du Pont Gelex No. 2, 45 pct strength; Gelex No. 3, 40 pct strength; and Extra C and Extra C-1 explosives. These tests indicated that good fragmentation is obtained with the Gelex No. 2, 45 pct strength, with the smallest consumption of powder per ton of rock broken. Further tests are to be made, but this explosive has been adopted as a constant in current experimental work with heading rounds.

Charging a round in a 27 by 60 ft heading such as described above is time-consuming. Stagings were required, and handling the explosives to the stagings was difficult and hazardous. A special piece of equipment was designed and built from which to charge the blastholes. This unit con-

sists of a wooden, 5 by 10 ft platform mounted on a Wagnermobile fork-lift truck (Fig 5). The truck is powered by a diesel engine and has a power hoist for raising and lowering the platform from which the miners charge the explosive into the drill holes. In addition, there is a ladderway up the side of the hoist frame and a remote-control cable to permit lowering of the platform by the miners working on it. The man-hours required for blasting have been reduced by about one-third through the use of the unit. At present, two miners can charge and blast a round in 5 hr. The rounds are loaded with three settings of the rig. The platform is of adequate size to allow carrying enough explosive to charge all the holes for each setting, thereby simplifying the explosives-handling problem.

No adequate or safe mechanized process could be found for tamping explosive into the blastholes. Experiments in which only the last cartridge in each hole was tamped indicated no apparent loss in blasting efficiency. At present, 1¾ by 8 in. cartridges are used in 1⅞ or 2 in. constant-diameter blastholes, and only the last cartridge in each hole is tamped.

Considerable experimental work remains to be done to perfect the drill pattern, to ascertain the optimum quantity and the best grade and type of explosive, to determine the best sequence of firing the blastholes, and to find the optimum ratio of diameter of drill hole to length of column of explosive in the hole.

FIG 5—Mobile blaster's platform from which to charge blastholes in advance heading of the underground quarry.

FIG 6—A 3 cu yd electric shovel loading a 15-ton Euclid dump truck on advance heading of underground quarry.

Loading and Transportation

Preliminary studies indicated that a continuous-type loader discharging directly onto a conveyor belt, which, in turn, would transport the broken shale to the crushing plant, would be the most efficient ultimate practice of handling the broken oil shale. This procedure was not adopted, because no standard continuous-type loading equipment capable of loading the large fragments of broken oil shale (up to 5 ft in diameter) is made, nor are conveyor belts made to handle such material. It was then necessary to accept standard loading and transportation equipment such as is used in quarries.

A standard 2½ yard, Bucyrus-Erie electric shovel with a special short boom to permit working under a 25 ft ceiling was chosen for loading the broken shale. As the shale is relatively lightweight (16 cu ft to the ton in place), the 2½ yard dipper was replaced with one of 3 cubic yards capacity. Two 15-ton Euclid diesel end-dump trucks were obtained from the Navy, and later a third truck of the same size was purchased for transporting the shale. Fig 6 shows the electric shovel loading a dump truck. The electric shovel appears to be the largest unit that can work efficiently in the 27 ft high by 60 ft wide openings; a larger dump truck, however, might be more efficient for transporting the oil shale.

The question always is raised as to the advisability of using diesel equipment underground. It follows that a part of the program at Rifle is to demonstrate under what conditions diesel equipment may be used in large underground workings.

The objectionable constituents of exhaust fumes from a diesel engine are carbon monoxide, oxides of nitrogen, and aldehydes. Carbon monoxide and the oxides of nitrogen are toxic gases. The formation of toxic gases may be kept to a minimum in diesel-engine exhausts by proper adjustments to allow a maximum amount of intake air per pound of fuel used. It has been found that the exhaust gases are diffused in the atmosphere of the large mine openings and that harmful concentration of the toxic gases does not occur.

The aldehydes, although not particularly harmful, have a characteristic sharp, suffocating odor and, even in small quantities, cause irritation to the eyes and respiratory passages. During

FIG 7—Portable scaling rig from which to scale loose rock from roof and pillar walls on advance heading of underground quarry.

the period before mechanical ventilation was installed at the oil-shale mine and when there was no natural movement of air (the outside and inside temperatures being the same), concentration of aldehydes from the diesel trucks in a working place became intolerable. These conditions exist only during short periods in the spring and the fall; during the remainder of the year natural ventilation is adequate.

Ample and adequate ventilation is requisite for the use of diesel equipment underground. It has been recommended that the minimum volume of ventilating air required for operating diesels underground is about 75 cfm per brake power.[4]

The elimination of the aldehydes from the exhausts of diesel engines to be used underground would be desirable even where ventilation is good. Currently, two methods to remove aldehydes from diesel exhausts are being investigated at the Rifle mine. One of the methods is to scrub the exhaust gas with a solution of sodium sulphite in water, using hydroquinone as an inhibitor.[5] The other method is to pass the exhaust fumes through a catalyst to remove the aldehydes. This latter system was developed by the Catalyst Research Corp. of Baltimore, Md.

Scaling

In any underground mine it is necessary to inspect the roof stone and walls and pry off any loose rock that might fall and cause injury to personnel or damage to equipment. At the oil-shale mine, where the pillars will eventually extend 70 ft above the floor, it is especially essential. Scaling is an important item of cost, and special equipment is required, so that the work may be done efficiently. A scaling rig (Fig 7) was acquired for use on the top level; it comprises a traveling crane equipped with a self-leveling platform, according to a design made at the oil-shale mine. Two men working on the platform remove loose rock from the roof and the upper parts of pillars by means of aluminum rods with steel tips. A small percussion drill can be mounted on the platform for drilling loose slabs of rock not easily pried off. Similar equipment capable of reaching a greater height is to be obtained as the lower levels are advanced.

Ventilation

Forced ventilation is supplied by a 60,000 cfm, low-pressure fan. Doorways have been built in each of the two entrance adits to the mine. The fan is installed in a 20 sq ft opening in a door; it can be moved from level to level, depending upon which level is being worked.

Facilities

POWER

Electric power is supplied in the mine at 2300, 440, and 110 volts, the 2300-volt circuit being used for the shovel. Several floodlights are installed on each piece of mobile equipment to ensure adequate lighting of the working places. In addition, permanent lights are suspended from the ceiling along the main haulage opening and at all plug-in stations.

The power lines are buried in trenches from the main substation into the working area. Throughout the working area, they are carried along the roof stone with drops to plug-in stations at convenient locations on each pillar.

WATER AND COMPRESSED AIR

Calculations made during initial operations showed that the cost of burying and moving air and water lines on the advancing levels of a commercial oil-shale mine would be an important item of expense. Moreover, loss of air pressure because of long air lines would reduce drilling speed with pneumatic drills, and the air and water lines would interfere with other work. A movable compressor assembly has been designed and is under construction. This unit will have two 750 cu ft electric air compressors, an air receiver, and a water tank. Air and water lines will not be required with this equipment, with a consequent saving in operating costs. The compressor motors will take the same voltage as the shovel, and the same outlets may be used interchangeably between compressor and shovel. A compressor and a shovel would not be working in the same heading at the same time.

Water for the experimental mine is piped in from a reservoir on the mesa. Water in a commercial mine would be trucked to where needed for drilling and wetting down broken piles of rock.

Test Run No. 1

The essential equipment to conduct a unit mining operation had been assembled by August 1948. A 20-day test run was made in August and September; each phase of the operation was completed in a single shift each day. Two 60 ft and two 50 ft headings were available for the test. The test was conducted to demonstrate the unit production of each phase of the operation, to obtain operating and cost data, and to assemble information that might be helpful in improving mining technique.

A total of 10 miners was assigned to work underground. Two miners on the jumbo drilled a 10 ft round each shift. Two miners in another heading loaded and blasted the round previously drilled. The broken shale in a third heading was loaded by one shovel operator and transported one-third of a mile to a stockpile by two truck drivers; a bulldozer operator cleaned up fly rock. The face of a fourth heading was scaled preparatory to drilling by a 2-man scaling crew. Two engineers and a statistical clerk were assigned full time to the test as bosses and to take and record pertinent data.

During the test run an average of 840 tons was mined each shift for a total production of 16,800 tons. Production per man-shift for underground labor was 81 tons, or 56 tons per man-shift total labor. The operating cost was $8,352, or $0.497 per ton.

The tons that could be loaded in a

Table 1 . . . Summary of Costs—First Test Run in Underground Quarry

	Labor[a]	Power	Fuel	Explosives	Other Supplies	Maintenance	Totals
Direct operating costs:							
Drilling	$0.028	$0.020			$0.054	$0.016	$0.118
Blasting	0.037			$0.106		0.002	0.145
Loading	0.032	0.005	$0.006			0.015	0.058
Transportation	0.029		0.007		0.008	0.005	0.049
Scaling	0.025		0.001		0.001	0.003	0.030
Direct supervision	0.042						0.042
Total	0.193	0.025	0.014	0.106	0.063	0.041	0.442
Indirect operating costs:[b]							
Engineering	0.007						0.007
Miscellaneous	0.005		0.001		0.002		0.008
Leave and vacation pay; 17.1 pct payroll	0.040						0.040
Total	0.052		0.001		0.002		0.055
Totals	0.245	0.025	0.015	0.106	0.065	0.041	0.497

[a] Some labor included in "Maintenance."
[b] Does not include general supervision, office expense, depreciation, or interest on investment.

shift by the shovel has been the unit to which other phases of the mining were to conform. The test indicated that this capacity would be 1400 to 1500 tons. It was demonstrated that the drilling and blasting phases could be completed in 5 hr. It would appear that by the addition of the longer slide on the jumbo, a round to break this tonnage could be drilled in a shift; the longer round also could be charged with explosive in a shift by two men. The overall tons per man-shift underground thereby would be increased nearly 50 pct.

The summary of costs is shown in Table 1, and a summary of engineering data is shown in Table 2.

Table 2 . . . Test Run No. 1—Engineering Data

Labor Item	Tons per 8-hr Man-shift	
	Underground	Total
Drilling	425	300
Blasting	354	337
Loading	382	306
Transportation	416	352
Scaling	458	440
Direct supervision	420	420
Engineering	2,440	2,440
Total force	81	56

Power and supplies		
Power kw-hr per ton:		
Drilling	0.85	
Loading	0.27	
Utilities	0.13	
Total		1.25
Explosives pounds per ton broken		0.56
Tons broken per foot hole		0.84
Feet holes drilled per drill bit		78.30
Tons per pound drill steel broken		6.50
Tons per load hauled		16.25
Tons hauled per gallon fuel		40.20

The highest single item of expense was $0.054 for drilling supplies; of this amount, nearly $0.04 cents was for broken drill rods. It is hoped that investigations now under way will bring this cost of drill steel down to not over $0.02 per ton of oil shale broken.

The labor cost of drilling ($0.028) and of charging the drill rounds ($0.037) will be reduced by drilling longer rounds. The cost of explosives was $0.085 per ton. Recent improvements in the distribution of explosive in the drill holes indicate that a round can be broken with less explosive; the saving in cost may be $0.01 per ton.

The labor cost of loading was $0.032. The shovel has a greater capacity than was utilized in the test run. When larger tonnages are handled, the labor cost will be reduced. The labor cost for transportation, however, probably will remain the same ($0.044).

During the test run, the full time of two scalers was required to prepare the drilling faces. There was not enough time to inspect adequately the roof and pillars in the rest of the mine. Although longer rounds will reduce the amount of face scaling per ton mined, the present cost of 2.6 cents a ton probably is low.

The results of the test run were encouraging; they show that the original goal is possible.

Summary

Among more important accomplishments to date are:

1. Determination of room-and-pillar dimensions for mining the Mahogany Ledge by an underground method.

2. Selection and development of a large-scale mining method for demonstration of low-cost mechanized mining.

3. Development of a hard-surfaced rock bit for drilling over 70 ft in oil shale before resharpening is necessary.

4. Design and development of a four-machine, multiple-drill carriage with which two miners can drill an 84-hole round 10 to 15 ft deep in one shift.

5. Design and procurement of a fork-lift truck from which to charge blastholes on the top level, and development of a charging technique for reducing charging time.

6. Selection of an optimum size electric shovel for loading broken oil shale and equipment for transporting it to the stockpile.

7. Design and procurement of a self-leveling platform on a tractor-mounted crane from which to scale loose rock from roof and pillar walls.

8. Demonstration, by means of an actual production test run, of equipment performance, mining costs, and mining technique.

The usual number of failures have occurred. About a year and a half was spent in the design and fabrication of a first jumbo; it proved a failure in one shift. The same general design, however, was used for the second jumbo, which was used in the test run. Moreover, the second jumbo had to be modified for the use of 15 ft slides. The effect upon costs of breakage of the 10 and 15 ft drill rods was overlooked until after drilling of long rounds was commenced.

Much work remains to be done in perfecting procedures for drilling and blasting the top heading.

Efforts to date have been confined largely to the top level. Drilling and blasting procedures for breaking the lower benches are yet to be developed. An important point now under discussion is to determine whether the part of the Mahogany Ledge which is below the top level is to be mined in one or two benches.

References

1. Carl Belser: Oil-shale Resources of Colorado, Utah, and Wyoming. TP 2358, *Petr. Tech.* (May 1948); *Trans.* AIME (1949) 179, 72.
2. F. D. Wright and P. B. Bucky: Determination of Room and Pillar Dimensions for the Oil-shale Mine at Rifle, Colorado. TP 2489, *Min. Tech.* (Nov. 1948); *Trans.* AIME (1949) 181, 352.
3. Tell Ertl, John R. Wagner, Jr., and Ernest E. Burgh: Development of a Successful Hard-surfaced Bit for Drilling Oil Shale. U. S. Bur. of Mines, *R-I.* 4177 (1948) 8 pp.
4. J. H. East, Jr., and E. R. Maize: Diesel Power for Underground Haulage. TP 2384, *Min. Tech.* (July 1948); *Trans.* AIME (1949) 181, 274.
5. R. F. Davis and M. A. Elliott: The Removal of Aldehydes from Diesel Exhaust Gas. *Trans.* ASME (Aug. 1948) 745.

Enhancement and Hazard Factors as Related to Mine Valuation

By J. MURRAY RIDDELL,* Member AIME

Introduction

The method of treating hazards wherein value is decreased, is cited by R. D. Parks.† Quite properly, the theory of probabilities is made use of when multiple hazards are under consideration. E. F. Fitzhugh, Jr.‡ deals with the enhancement phase graphically and uses percentage of expectancy as derived by a study of conditions and the selection of a chance factor. It is believed that both of the authors referred to fully recognize the part which human judgment plays, and as coupled with experience, training, and the application of the theory of probabilities; in that respect the composer of this paper is in accord.

Within the past year, the task of arriving at a mathematical method for handling the enhancement phase, and, additionally, coupling the negative and positive phases, was explored. In citing the hazard, or negative phase, reference is made to the text by Parks.

Types of Items for Consideration

On the hazard, or negative, side some of the common items to be considered are:

1. Subsidence and resulting damage.
2. Flowage of water above that anticipated.
3. Geological.
   (a) Decline in quality of probable ore, and/or
   (b) Decline in quantity of probable ore.
4. Depressed economic conditions.
5. Litigation.

Similarly, on the enhancement, or positive, side common items to be considered are:

1. Flowage of water below that estimated.
2. Geological.
   (a) Increase in quality of probable ore, and/or
   (b) Increase in quantity of probable ore.
3. Elevated economic conditions.
4. Litigation.
5. Technological advance in the art.

In all of the above items no consideration is given to placing a value on, or giving consideration to, possibilities.

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† R. D. Parks: Examination and Valuation of Mineral Property. Cambridge, Mass. Addison-Wesley Press, Inc.

‡ Edward F. Fitzhugh, Jr.: The Appraisal of Ore Expectancies. TP 2090, *Min. Tech.* (Jan. 1947); *Trans.* AIME (1948) 178, 143.

Hazard Phase

For example, referring to Table 1, the estimated normal present value (Vp) of a property, exclusive of risk consideration, is taken as $100,000. If subsidence affects the usefulness of the shaft, the present value of the property will decrease to $60,000, and it is judged that there is a 1 in 4 chance that the shaft will be impaired; consequently, if subsidence took place, the present value would be reduced ($100,000–$60,000) $40,000, but since the chance is 1 in 4, the allowable reduction would be only one-fourth of $40,000, or $10,000, or a discount of 10 pct (hazard factor) of the original value; the related safety factor is taken as unity minus 0.10, or 0.90. Thus, the original Vp, $100,000, multiplied by the safety factor ($100,000 × 0.90) gives $90,000, which is the adjusted present value of the property in this single instance.

Additionally, there is a water hazard, which, if encountered, will reduce the present value to $85,000. The chance is 1 in 3. Following through with the same reasoning as shown above, the derived safety factor will be 0.95.

To arrive at a single multiplying factor which will express the combined risks, the two safety factors are multiplied together, $0.90 \times 0.95 = 0.855$. That factor when multiplied by the original Vp will give the adjusted, and

Table 1 . . . Hazard Phase

Present value of property, exclusive of risk consideration, estimated, Vp = $100,000

Nature of Risk	Chance	Potential Value	Potential Reduction A	Allowable Reduction B	Hazard Factor C	Safety Factor D
Subsidence	1 in 4	$60,000	$40,000	$10,000	0.10	0.90
Water	1 in 3	85,000	15,000	5,000	0.05	0.95

Combined safety factors = 0.90 × 0.95 = 0.855

Adjusted present value = $100,000 × 0.855 = $85,500

Note: A = Vp − potential value

B = A × chance ratio

C = B ÷ Vp

D = unity − C

Both may happen, 0.10 × 0.05 = 0.005

Subsidence may happen, water may not happen, 0.10 × 0.95 = 0.095

Water may happen, subsidence may not happen, 0.05 × 0.90 = 0.045

Both may not happen, 0.90 × 0.95 = 0.855

1.000

Table 2 . . . Enhancement Phase

Present value of property, exclusive of enhancement consideration, estimated, Vp = $100,000

Nature of Risk	Chance	Potential Value	Potential Increase	Allowable Increase	Security Factor	Improbability Factor
Geological	1 in 6	$175,000	$75,000	$12,500	0.125	0.875
Technological Advance	1 in 2	140,000	40,000	20,000	0.200	0.800

Combined improbability factors = 0.875 × 0.800 = 0.700

Multiplying factor = (1 − 0.700) + 1.000 = 1.300

Adjusted present value = $100,000 × 1.300 = $130,000

Both may happen, 0.125 × 0.200 = 0.025

Geological may happen, technological may not happen, 0.125 × 0.800 = 0.100

Technological may happen, geological may not happen, 0.200 × 0.875 = 0.175

Both may not happen, 0.875 × 0.800 = 0.700

1.000

weighted, value of the property, or $85,500. The procedure is the application of the theory of probabilities to the problem.

Enhancement Phase

Referring to Table 2, the original Vp remains the same as previously quoted, $100,000. The involved enhancing phases under consideration are two, namely: (1) probable ore extension, geological; and (2) the probability of technological development which would elevate value. In the first case the chance is considered as 1 in 6, and in the latter 1 in 2; correspondingly, the respective enhanced present values are taken as $175,000 and $140,000.

Enhancement and improbability factors are derived in a manner like the hazard and safety factors of Table 1.

It will be noted that the multiplying factor is expressed as (1 − 0.70) + 1 = 1.30; that raises the question, why? Again it is a play on the theory of probabilities.

Since the improbable portion of the last entry is 0.700, then the probable portion is 1.000 minus 0.700, or 0.300; further, it is then necessary to add unity, 1.000, in order to care for the base figure.

Combination of Hazard and Enhancement Phases

Should a condition exist where both phases, hazard and enhancement, surround a property, and wherein a final adjusted present worth figure is desired, such can be obtained by combining, by multiplication, the original present worth and the respective multiplying factors, thus:

Final adjusted present value = $100,000 × 0.855 × 1.300 = $111,150.

Conclusions

It is believed that the foregoing method of caring for situations of the kind described is basically sound. However, it is recognized that the selection of the chance factor is a matter of personal judgment based on experience, observation, and deduction; it could well be the average of the judgment of two or more appraisers.

The foregoing example has made no mention of formula to be used in arriving at the respective present values under given conditions, nor rates of interest to be considered, because they are outside the premise of the subject matter.

The Economics of Geophysics in Mining Exploration

By J. J. JAKOSKY,* Member AIME

The strategic importance of the metallic minerals in our industrial economy, and the declining rates of discovery have focused attention on means of exploration for new mineral deposits. A consideration of exploration techniques leads to an attempt to evaluate the effectiveness of geophysics as a tool for mining exploration. One means of evaluation will be to compare the use of geophysics in petroleum exploration with its possible uses in mining.

Geophysics in Petroleum Exploration

During the past twenty years, the petroleum industry has established an effective exploration technique. Geology is the basic tool in those areas where reliable predictions can be made from surface conditions. In the other areas, where the geological studies are inadequate, they must be supplemented with geophysics or direct exploration, such as drilling. Since geophysical work is far less costly than any form of direct exploration, it is used almost exclusively as the means for obtaining the desired subsurface information.

The geological and geophysical techniques are credited with locating sites which yielded one producer for three dry holes during the year 1947.[1] For the wells located without geology or geophysics, there is a ratio of one producing well to sixteen dry holes. From these figures it is seen that the geological and geophysical techniques are more than four times as successful as the nontechnical exploration.

It will be in order to consider further this ratio of one producer to three dry holes. The geophysical methods in use today† do not pretend to locate oil directly; their function is to locate anomalies or structures favorable for the accumulation of oil. For a producing oil well we must have not only structure, but also other favorable conditions, namely: petroliferous source beds, the required porosity and permeability in the reservoir rocks, an impermeable cap rock over the reservoir, and the necessary water or gravity drive to force the oil into the bore hole. Since the geophysical work can only detect and sometimes delimit the anomaly, these other necessary conditions can be determined only by direct exploration. The success of modern geophysical work in locating and limiting the structure itself is remarkably high, probably over 95 pct accurate.

Geophysical work renders an important service in the delineation of the structurally unfavorable areas and their elimination from the drilling phase of the exploration program. When attempting to locate any material of scarce occurrence in the earth, it is of paramount importance to know where *not* to dig. This elimination of barren areas is the least appreciated but is of great economic importance. For illustration, the difference between one producer to three dry holes, and one producer to sixteen dry holes, represents a saving of thirteen drilled wells, which would require an expenditure many times the cost of the geophysical work that might have revealed the nonfavorable structural conditions.

The percentage of geophysically-located wells necessarily will continue to increase in the statistics of future years, as the search for oil is extended

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[1] References are at the end of the paper.

† Excluding the geochemical method, which is still undergoing development.

into the areas where more geophysics must be employed. In the United States, the most important undeveloped petroliferous areas remaining today are the covered or masked areas, complex fault accumulations, and the stratigraphic traps created by unconformities, pinch-outs, overlaps, changes in porosity or sedimentation, and lensing. These areas generally are not amenable to geological studies, and must be attacked by geophysical work or direct drilling.[2]

The high trend in the use of geophysics for petroleum exploration is increasing in spite of the increased costs occasioned by more intensive and detailed work. During 1947, over $90,000,000 was expended for seismic work. During this same period, the expenditures for gravity work totaled about $7,500,000. Probably an additional $7,500,000 was spent on the air-borne magnetic, electrical, geochemical, and other methods. The total expenditure for petroleum geophysics last year was therefore in the neighborhood of $105,000,000.[3] During this same period, the value of the crude oil, natural gas, and natural gasoline produced was in excess of 2.5 billion dollars. This means that today the petroleum industry is spending about 4.2 pct of the gross value of the oil produced on direct geophysical work, and perhaps another 5 to 10 times that amount on geological and other exploration necessary to find new oil. Although this large expenditure is made for technical guidance, the history of the industry clearly shows that the greater success factor of the technically-located wells more than pays for this cost by the savings effected in not drilling the unfavorable areas.

Now let us examine the use of geophysics in mining. The application of geophysics to mining exploration is so spasmodic and spotted that we have no reliable scout reports showing the number of crews operating. The best information that I have been able to obtain comes from the state mining bureaus, consulting organizations, and private mining companies. This information indicates that about $450,000 per year will cover the entire expenditures for actual field work and applied research. During that period, the annual value of the metals mined was about $1,800,000,000. This gives an expenditure for mining geophysics of about $\frac{1}{40}$ of 1 pct. The petroleum industry is therefore spending a percentage that is more than 165 times as large as that being spent by the metal mining industry.

Exploration Procedures in Petroleum and Mining Exploration

There is a fundamental reason why geophysical work has proved to be such an important tool in petroleum exploration, and why as yet it is so relatively unimportant in mining. This reason is one of procedure, based more on mining precedent than on technology or economics. Over a period of years, the petroleum explorer has learned that the best way to discover a new oil field is to choose first an *area* which should contain the necessary petroliferous source beds. The next general step is to obtain the required permission to trespass the land and conduct the investigations. The locale is kept sufficiently large to allow data to be obtained on a regional scale. As the broader subsurface picture develops, the area of economic importance becomes defined. Local property boundaries are not considered too dogmatically until after the subsurface picture begins to take form.

In mining exploration, however, we usually find a different type of thinking guiding the exploration program. It is true that the mining property may be located in an area where conditions are favorable for ore occurrence. From that point on, however, the exploration attention far too often is rigidly focused within the narrow limitations of specific claim boundaries. The chief criticism of mineral exploration today, from the geophysicist's point of view, is that a sufficiently broad overall picture is not obtained before concentrating on detailed exploration.

Application of Geophysics to Mining Exploration

The application of geophysics to mining exploration may be divided into two general categories: first, its application to areas where detailed studies are dictated, and second, its application to areas where reconnaissance studies may be employed to delineate the zones of interest.

To date, the largest application of mining geophysics has been the detailed type of survey, usually applied to operating or previously worked properties. In such areas, the property lines and claim corners far too often constitute rigid boundaries of the area to be examined. The problem handed to the geophysicist then becomes one of locating an ore body within the confines of that particular property.

The application of geophysical work under these conditions usually is a distress measure. The geophysical work is not being done as part of an intelligently planned exploration program. Far too often, it is resorted to as a last attempt to stave off shut-downs, or to aid in future promotion and financing. When geophysics is employed in this way, it has very little chance of achieving success.

It will be most difficult to fix a reliable statistical figure showing the chance for success of any exploratory program seeking to locate new ore in working or previously worked areas. However, when we consider the high percentage of prospects that are abandoned each year, we know that the chance of locating such ore bodies is usually quite remote.

Even though the chance of finding new ore bodies or extensions of known bodies may be discouraging, geophysics can serve a most useful, albeit negative, function in such mining operations. The history of mining and oil exploration clearly indicates that the greatest single factor causing useless loss of capital has been the common human trait of not knowing when to stop. Human nature being what it is, every attempt is made to prolong the life of a mining venture and to operate the property in hopes that the operation eventually can be profitable. Oftentimes, geophysics can serve as a means of evaluation and can be of definite value in preventing the useless expenditure of the remaining capital assets.

An examination of this type may be illustrated by a geophysical survey of a mine in central California, located in a complexly faulted area of paleozoic sediments (comprising limestones, dolomitic limestones, quartzites, and shales), intruded by numerous dikes and sills, (monzonite porphyry, diabase, and quartz-diorite porphyry). These formations are cut by numerous post- and pre-mineral faults, some of which may have cut off or displaced the ore bodies. The complicated subsurface conditions make it impossible to locate any faulted extensions of the previously mined ore bodies, based upon geological deduction alone. The rocks in that area have densities vary-

ing from 2.2 to 2.8, while the massive galena ore has a density of 7.8, and the oxidized ore a density of 5.2. The surface topography is rugged, but of a configuration amenable to reliable topographic correction. Because of the difference in density between the country rocks and the ore, a gravity survey offered the most expedient and economical means of ascertaining the information desired.

In consultation with the mining engineer of this company, a decision was reached regarding the minimum size of ore body to be considered commercially minable. Calculations were then made to determine the gravimetric effects of such an ore body, at the probable depths, as indicated by the faults encountered in the present underground workings. These calculations showed that such an ore body, if present, would exert a local gravimetric influence in excess of ten times the probable error in the work, and would therefore be readily detectable. Furthermore, the extensive underground workings would allow measurements to be made much closer to the probable places where such faulted ore bodies might exist.

The results of the geophysical work showed that there were no gravimetric anomalies of magnitude even approaching that to be expected from a body of the size under consideration. It was concluded therefore that no such ore body existed. From the viewpoint of finding new ore, the work was unsuccessful. However, from the viewpoint of operation planning and evaluation, the work was most advantageous, because it gave a good answer to the question of "when to stop."

Reconnaissance Geophysical Work in New Areas

I would now like to discuss the application of geophysics in reconnaissance exploration. Here again we can try to evaluate the possibilities of success by studying the history of mining exploration. Estimates by numerous mining engineers indicate that the average number of prospects examined will run from 1000 to 5000 before one property suitable for commercial operation is found.

With such great odds against locating an ore body, it is clearly apparent that the exploration program must be directed primarily toward screening an area, and at the lowest cost per acre. In many cases this can be accomplished by the following steps: (1) geological studies, with reference to structure, intrusive igneous bodies, and mineralogical guides in the area; (2) reconnaissance geophysics over the geologically favorable areas; then (3) detailed geophysical examination of the more favorable zones, to locate anomalies that might be caused by commercial mineralization; followed by (4) direct exploration, such as trenching, shaft, tunnel, or drill hole, to evaluate the anomalous condition.

The use of this technique may be illustrated by a survey in Inyo County, Calif.[4] Previous history showed that a lead-zinc sulphide ore occurred in the limestone, adjacent to a limestone-monzonite contact. This contact initially was mapped at four outcrops over a distance of about a mile. Between outcrops the contact was covered by fill material. This type of sulphide is a good electrical conductor and its presence may be indicated by determining the anomalies or zones of better electrical conductivity. Reconnaissance measurements were made along the indicated line of contact, using an inductive method. This was followed by detailed direct current measurements to map the zones of better electrical conductivity. Two main zones of higher conductivity were mapped, one near an old tunnel. A crosscut to the contact encountered ore, consisting chiefly of "lead sulphide replacements, and the large oxidized ore bodies adjacent to them, which now have been mined continuously since 1940."* Later, the development work was extended to cut the second conductive zone, which was at a depth of about 300 ft below the surface. This zone proved to be high-grade sulphides, nearly underlying the old oxidized ore body previously mined and abandoned.

A good example of a regional reconnaissance survey involves the use of magnetic work which led to the westward extension of the Rand in South Africa.[5] Magnetometers were used to map the sub-outcrop of a metamorphosed ferruginous shale formation buried under approximately 2000 ft of unconformable dolomite. The buried formation is comprised of vertically bedded quartzites, slates, shales, some volcanics, and the gold-bearing conglomerates. The slates are magnetic, and their stratigraphic relation to the main gold-bearing reef is well established. Mapping the magnetic anomaly associated with the slate, therefore, served to locate the desired reef which carries the gold values. As a result of this work, it is estimated that the potential gold reserves of the Rand have been increased about 15 pct.

Another example of regional, geologically-guided geophysical work is that conducted by the International and the Falconbridge Nickel Companies in the Sudbury District, Ontario, Canada.[6] The ore is massive nickel and copper sulphides, with sufficient pyrrhotite to make it magnetic. The surface covering is chiefly glacial out-wash, at depths varying from 50 to 300 ft. After completion of the reconnaissance work, electrical methods were used to check the important magnetic anomalies. The subsequent exploration results have established the success of this type of exploration technique as applied to that area.

Geophysical Work Versus Direct Exploration

Usually, geologically-guided geophysical work may be done more economically than geologically-guided direct exploration. Quite often a comparison is made between the cost of a geological examination and the geophysical examination of a mining property. This comparison is not too enlightening, because geological work alone in the usual complex mining area is most limited in its ability to predict the subsurface conditions. Dips and strikes of exposed rocks must be extended underground with extreme caution, in a folded and faulted area. As the experienced mining engineer and geologist also knows, geological prediction is greatly handicapped until enough development has been done to establish the local habits of ore genesis and occurrence. Geological work then must be supplemented with direct exploration, such as drilling. The cost of such geological work and the necessary direct exploration usually is far greater in expenditure of both time and money, than geologically-guided geophysical work.

Whether geologically-guided direct exploration or geologically-guided geophysical reconnaissance is the best procedure will depend upon local conditions and the information desired. For instance, the cost of a single 300 ft drill hole is equivalent to the cost of geophysical work over many acres.

* Personal communication from H. E. Olund, U. S. Bureau of Mines, to S. E. Stein, Oct. 4, 1948.

The drill hole should give detailed and specific information of the conditions along the exact path traversed by the drill. On the other hand, the geophysical work should give general information over a relatively large area. Obviously, there can be no fixed rule as to which is the more expedient technique. Generally, however, the geologically-guided geophysical work will be the more economical during the reconnaissance stage, while obtaining the overall picture of the area. Then, the direct type of exploration may be employed to determine the economic value of the geophysical anomalies.

Depth of Geophysical Work

The depth to which reliable geophysical work may be conducted in the exploration for minerals is governed almost entirely by the size and configuration of the subsurface feature, and the physically measurable differences in situ between that feature and the country rocks. The choice of a geophysical method is also important. For instance, a vertical plug or ore deposit about 60 ft across and 200 ft high, having a density about three times that of the surrounding medium, could produce a detectable gravitational anomaly (in an area where the necessary corrections may be made for topography and subsurface changes in formation) at depths of about 700 ft. On the other hand, this same quantity of sulphide ore, if extended and existing as a stringer of mineralization along a vein, might not be detectable by gravity work to a depth of even a few tens of feet. However, such a long extended ore body could easily be detected by the electrical methods, which should be able to show its presence to depths of perhaps 100 to 300 ft.

Even with a depth limitation of one hundred or a few hundred feet at best, there are very large areas where mining geophysics may be useful. In Canada, over 90 pct of the pre-Cambrian shield is covered with shallow water and overburden. In the United States and Mexico there also are many thousands of square miles covered with alluvial fill, lake beds, volcanic flaws, etc., underneath which commercial mineralization probably exists. The Basin and Range Province of the western United States is an outstanding example of this condition.

Our surface areas have been prospected quite thoroughly and the mines of the future will come chiefly from the mineralized zones hidden from surface prospecting today.

Type of Equipment

The complexity of geological conditions which exist in a majority of mining areas is in contrast to the relative simplicity of structure governing the accumulation of petroleum. Discovery of these simple petroleum structures with their large size is usually accomplished with a single geophysical method. In mining exploration, however, we are dealing with relatively small features embedded within a complex environment, and this usually indicates the desirability of using more than one geophysical method. Perhaps this can be explained by considering the familiar analogy of looking at a building from only one side. A single view from any one angle differs from the view obtained from another angle. Two views taken from different angles yield information regarding the size and type of building far in excess of that furnished by either of the single views alone. Knowing the type of ore and its occurrence, the geophysical methods should be chosen to give this complementary type of data.

For instance, the successful use of the magnetometer in reconnaissance exploration for the nickel-bearing ores in Canada is predicated upon the fact that pyrrhotite, a magnetic material, occurs with the nickel. There are, of course, many other conditions that could cause a magnetic high in that area, such as disseminated magnetite or intrusive basic rocks. To differentiate between the sulphide ore desired and some other magnetic condition, a traverse or two with one of the electrical methods would give the necessary complementary information. The self-potential method, when ground water conditions are correct, will detect sulphide bodies, such as pyrrhotite, nickel, etc. If, therefore, under these particular conditions, a self-potential survey discloses an active electrical negative center over the same general area where the magnetic high was mapped, we can be fairly certain that this dual condition is caused by the pyrrhotite in the ore. Drilling or other exploration would then be recommended. If, however, an active electrical center is not obtained over the magnetic high, the chances are that our magnetic work has merely mapped a basic igneous rock or a concentration of magnetite.

Quite often, two types of geophysical measurement may be made during the same survey without an appreciable increase in cost. For instance, magnetic and gravity measurements can be made at each station with an increased time for reading which adds only about 20 pct to the total cost.

Complementary measurements allow more reliable interpretation, and in many cases actually result in a decrease in overall cost of the work by decreasing the detail which would be necessary if only one method were applied.

Interpretation of Data

Interpretation no doubt contains the greatest personal equation of any of the components of mining geophysics. This is due to the human inability of the interpreter to evaluate accurately the full significance of the geological and geophysical data, in terms of economic geology. Interpretation must be guided by experience. The subsurface is an extremely complex, three-dimensional region which the successful interpreter must diagnose with only the help of the far too often limited and incomplete data obtained from surface geological and geophysical work. For this reason, close teamwork of the mining engineer, or geologist, with the geophysicist is an important essential in proper planning of the work, and the interpretation of the data. There can be no substitute for this cooperation between the mining or geological and geophysical personnel.

Geophysical Methods for Mining Exploration

Because of the complexity of subsurface conditions, the geophysical crew must be equipped with the necessary apparatus to allow those different techniques to be applied which will give the most useful information for the least expenditure of time and money. Over a period of years, experience has shown that a properly organized geophysical crew will be able to cope with the problems encountered in the usual mining work, when equipped with the following methods:

1. Electrical: for determining the areas of better electrical conductivity, such as caused by sulphide ore bodies of an elongated configuration. The elec-

trical method must be capable of making rapid lateral measurements for reconnaissance, as well as detailed vertical measurements, and must be of a type which clearly differentiates the deeper, subsurface effects from the masking effects of near-surface inhomogeneities.

2. Self-potential: for determining negative centers, such as created by sulphide ore bodies undergoing oxidation.

3. Gravity: for determining areas of different gravitational pull, as created by massive sulphide or oxide ore bodies, buried contacts, or intrusives.

4. Magnetic: for determining areas of different magnetic susceptibility, such as caused by ores containing pyrrhotite, magnetite, etc., and the basic rocks, and for mapping buried contacts between sedimentaries and basic rocks, intrusives, and flaws.

5. Seismic: for measuring the relative velocities of the materials comprising the subsurface; for obtaining the thickness of fill materials and depth to bed rock, etc. The equipment should be capable of doing shallow work by the reflection or the refraction techniques.

6. Equipment for electrical logging of drill holes.

Geophysics in Drill Holes

Although diamond and core drills are not geophysical equipment, their use is so closely related to the use of geophysics that special mention should be made of equipment for electrically logging drill holes. The function of the geophysical work is to show where subsurface anomalies exist. When drilling rigs are available, they are one means of investigating these anomalies and of obtaining the most direct type of data at the minimum cost. Since drilling is often conducted contemporaneously with the geophysical work, it is advisable that the geophysical equipment include a portable electrical logging outfit. Many stories are prevalent in mining folk-lore, describing ore bodies that have been missed a few inches by the drill hole. Its use in mining exploration undoubtedly will prove to be as valuable as it is in petroleum exploration.

Success Versus Accuracy

It should be borne in mind that very seldom are subsurface conditions so simple that the geophysical measurements will serve as a direct means for locating ore. Under favorable conditions, the geophysical work will locate anomalies or zones that could be ore or perhaps any one or more of a dozen other conditions. Direct exploration must therefore be employed to determine the exact cause of this anomaly. The chief function of the geophysical work is to locate the anomalies.

In petroleum exploration, as has already been stated, geophysical work has a success record of about one producer to three dry holes. The conditions in mining are of greater complexity. Therefore, we must contemplate drilling many geophysical anomalies for each ore body discovered. The success record of mining geophysics should be judged upon its ability to locate these anomalous conditions where commercial ore may exist. Direct exploration will then evaluate the commercial possibilities of the geophysical anomaly.

The officials responsible for exploration planning in the mining industry should give more study to the possible role of geophysics in their exploration programs. They should then adjust their budgets so that geophysical work may be coordinated with the initial exploration planning. By so doing, geophysics can become part of the regional studies and be best utilized as a tool for exploration.

References

1. Lahee: Exploratory Drilling in 1947. A.A.P.G. *Bull.* (June 1948) **32** (6) 851–868.
2. J. J. Jakosky: Whether Exploration. A.A.P.G. *Bull.* (July 1947) **31** (7).
3. E. A. Eckhardt: Geophysical Activity in the Oil Industry in the United States in 1947. *Geophysics* (Oct. 1948).
4. J. J. Jakosky: Operating Principles of Inductive Geophysical Processes. *Trans.* AIME (*Geophysical Prospecting*) (1929) **81**, 138.
5. R. Kraham: Magnetometer Observations on the West Rand. *Jnl.* Chem. Met. and Min. Soc. of South Africa (March 1936).
6. F. Galbraith: The Magnetometer as a Geological Instrument at Sudbury. *Trans.* AIME (1945) **164**, 98–106.

CORRECTION FEBRUARY ISSUE

"The Flotation of Copper Silicate from Silica" By R. W. Ludt and C. C. DeWitt.

On page 49, column 3, the formula shown is the formula of the leuco-base of the dye. The general formula should have been reported as follows:

$$\begin{array}{ll} & C_6H_4{\cdot}N(CH_3)_2 \\ p\text{—}R\text{—}C_6H_4{\cdot}C & \\ & C_6H_4{:}N(CH_3)_2 \\ & \quad Cl \end{array}$$

Cyclone Operating Factors and Capacities on Coal and Refuse Slurries

By D. A. DAHLSTROM,* Junior Member AIME

Introduction

Although the liquid-solid cyclone is a relatively recent innovation in the field of coal preparation, various authors have already indicated three distinct applications to operations encountered in the modern tipple. Driessen's articles and work at the Dutch State Mines exhibited its possibilities in the beneficiation of fine coal with apparently high efficiencies down to the 200-mesh fraction.[1,2,3,4] Other publications point out its use as a recoverer, thickener, and preliminary dewatering agent of fine coal which in too many cases is being wasted due largely to former high operating cost limitations.[5,6] Finally, certain authors have emphasized the practicability of applying the cyclone to the elimination of coarse and fine solids from water slurries in the tipple in order to produce a water suitable for recycle purposes containing only minute particles far below the 200-mesh size.[6] This would result in a closed water system for many cases, with its accompanying economic and operating advantages to locations where water quantity and quality problems are severe; better operation of washing equipment using a consistent water devoid of injurious fine particles; lowered maintenance costs due to the lesser abrasion resulting when the fine abraiding particles are removed; and the greater ease of disposing of refuse streams of reduced volume containing greater percentages of solids.

While the three applications have been indicated to be feasible, only a meager amount of data is available on capacities and solid elimination efficiency as a function of design variables and cyclone friction loss. This information is essential for the optimum use and construction of the solid-liquid cyclone, and accordingly, work on the problem was initiated at Northwestern University.

For the unfamiliar reader, briefly the cyclone consists of a cylindrical section mounted above a truncated cone. The feed nozzle enters the cylindrical ring tangentially with the underflow nozzle permitting discharge of the concentrated solids located at the apex of the cone. The overflow nozzle through which the clarified water exits is centered in the cylindrical section at the top of the cyclone. Half sections of experimental cyclones will be found in Fig 1*a* and *b*. The feed slurry enters with a tangential velocity, thus creating a spiral pattern of high centrifugal force. The solid particles of sufficient size and gravity are ejected outward to the walls and spirally discharge to the underflow. Most of the water with uneliminated fine solids moves radially inward along the path of the outer

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TP 2633 F. Discussion of this paper (2 copies) may be sent to *Transactions* AIME before Oct. 30, 1949. Manuscript received Feb. 3, 1949.

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[1] References are at the end of the paper.

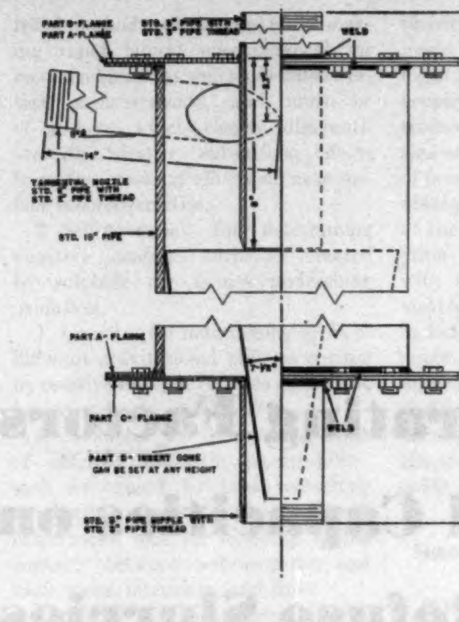

FIG 1a—Ten inch Wilmington cyclone, Northern Illinois Coal Corp., Wilmington, Ill.

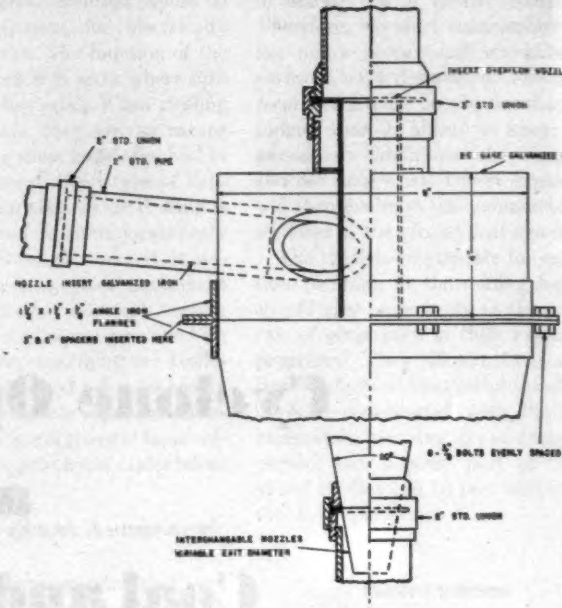

FIG 1b—Half section of 9 in. experimental cyclone.

spiral to a second inner spiral at the cyclone core to pass out the overflow. The latter spiral is the most critical fluid movement because of its small radius and higher tangential velocity. The centrifugal force which furnishes the elimination power will attain a maximum at this point.

To the operator, the factors of pressure drop, capacity, and solid elimination efficiency of the cyclone are of paramount importance. Naturally, if he is to design a cyclone for a particular situation, he must know what variables effect these factors and to what extent. From previous data and theoretical studies the following variables were considered to be of major significance in effecting one or more of the three factors:[4] (1) inlet nozzle diameter, (2) overflow nozzle diameter, (3) rate of cyclone throughput, (4) weight percentage of solids in feed slurry, (5) specific gravity of solid material, (6) separation between overflow and conical section, (7) included angle of the conical section, (8) percentage of total volume reporting to the underflow, (9) diameter of cyclone, and (10) type of underflow discharge.

If the effects of these variables can be definitely determined, the economic and operating balance to predict the optimum cyclone design for any application could be performed.

Equipment

In attacking the problem, it was decided that theoretical studies alone would be insufficient because results from actual tipple installations would be necessary for correlating purposes. Therefore, a cyclone utilizing a short length of standard 10 in. casing with removable sheet metal insert cones was constructed at Northwestern University and installed at the Wilmington, Ill., tipple of the Northern Illinois Coal Corp. processing recycle water. Fig 1a is a half section of this cyclone and indicates the flexibility of the conical section with respect to position and included angle. During the course of the test runs, the feed nozzle was changed from a 2 in. to a 2½ in. standard pipe.

For further industrial data, permission was obtained from the Truax-Traer Coal Co. to make test runs on their 14 in. Driessen cone, dewatering a fine coal slurry at the Kayford, W. Va., tipple.

The principal cyclone used for the theoretical studies is illustrated in half section in Fig 1b. By use of this construction, all the three nozzles, included angle, and separation between overflow and conical section, could be varied. Thus, of the ten important variables affecting operation, only one, cyclone diameter, could not be observed with this equipment. However, this study was made through the use of a 7 in. cyclone used and described in an earlier paper, and a newly constructed 3 in. cyclone. Both of these cyclones were of fixed dimensions and possessed included angles of 20°.

The equipment setup for the theoretical studies is illustrated in Fig 2. When running water only, the water was pumped from the sump tank by two staged centrifugals through a regulating gate valve to the cyclone. The pressure was measured at the inlet to the feed nozzle while overflow and underflow pipes discharged back to the sump tank. During a run, rate samples were taken from the overflow and underflow in weighing tanks for timed intervals, the feed being reconstructed from these data. The same procedure was used for solid runs except that a high-speed mixer was placed in the sump tank in order to maintain a consistent slurry concentration. In addition, small samples of overflow and underflow were taken for analysis work.

Pressure Drop Studies

For convenience in study, the problem was divided into two parts, cyclone pressure drop or energy loss, and solid

elimination efficiency. The two divisions will be correlated at the termination of the paper.

In considering pressure drop, it was necessary to refer to the gas-solid cyclone theory as a starting point. According to Shepherd and Lapelle, the capacity equation for the gas-solid cyclone is a function of inlet and overflow diameters and is expressed in terms of cyclone energy loss divided by the inlet velocity head as follows:[7,8,9]

$$F' = K' \frac{b^m}{e^n} \qquad 1]^*$$

As this equation is difficult to handle and usually involves a trial and error solution, the following transformation was made.

By definition, $F' = \frac{F}{v_i^2/2g} = K' \frac{b^m}{e^n}$

where F is the energy loss expressed as feet of fluid.

Rearranging and taking the square root gives

$$\frac{v_i}{\sqrt{F}} = \sqrt{\frac{2g}{K'}}\,\frac{e^{n/2}}{b^{m/2}} \qquad [2]$$

However, the gallons per minute of feed slurry is equal to

$$Q = \frac{60\pi b^2}{4}\left(\frac{1}{231}\text{ cu in. per gal}\right)12v_i \qquad [3]$$

or

$$v_i = 0.408\,\frac{Q}{b^2} \qquad [4]$$

Substituting for v_i in Eq 2 and rearranging, gives

$$\frac{Q}{\sqrt{F}} = \frac{19.7}{\sqrt{K'}}\,\frac{e^{n/2}}{b^{m/2-2}} \qquad [5]$$

This equation can be further simplified by combining all constants and exponents to one symbol, as follows:

$$\frac{Q}{\sqrt{F}} = K(e)^s(b)^t \qquad [6]$$

where $K = 19.7/\sqrt{K'}$
$s = n/2$
$t = 2 - m/2$

The term, $Q/\sqrt{F}$, has been designated as the capacity ratio and is the basic expression for any flow apparatus, i.e., capacity is a function of the square root of energy loss, and thus $Q/\sqrt{F}$ should remain constant for any constant dimension apparatus. It will be observed that Eq 6 is expressed in simple terms, easily measured, and involving no trial and error in its use. Thus, if valid, it represents a rapid and easy way of predicting either capacity or pressure requirements for any cyclone. It should be emphasized at this time that the term F represents the energy loss in the cyclone proper. In the complete installation, sufficient energy will have to be supplied to overcome all friction losses and potential and kinetic energy changes in the feed line and nozzle and overflow pipe and nozzle.

* Nomenclature is given on p. 344.

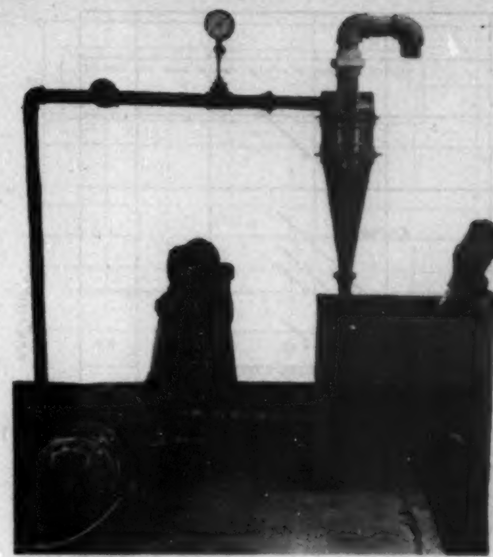

FIG 2—Test unit of 9 in. cyclone.

Taking the logarithm of both sides of Eq 6,

$$\log (Q/\sqrt{F}) = \log K + s \log e + t \log b \qquad [7]$$

As K, s and t have been assumed as constants in the above derivation, Eq 7 represents a straight line if either e or b are held constant. Therefore, if the theory advanced is valid, a plot of capacity ratio as a function of one diameter with parameters of the other should yield straight line curves on log-log paper. Furthermore, all parameters of one set should be parallel with a slope of either s or t. The K value can be determined from the intercept value for capacity ratio where the variable diameter is equal to 1 in. by use of Eq 7.

To test the theory's validity, water runs were made with the 9 in. cyclone varying the inlet and overflow diameters. By collecting rate samples of underflow and overflow, friction losses occurring before the cyclone inlet and after the overflow could be calculated. Finally, by applying Bernoulli's flow equation between the point of pressure measurement and the overflow exit pipe, the cyclone energy loss was determined. This method neglects the energy remaining in the underflow discharge stream. As this energy is largely present as rotational kinetic energy with the vortex type of discharge, it is difficult to measure. In order that this error would be small, underflow discharges were generally held to less than 5 pct by volume. However, it should be pointed out that to maintain the vortex underflow discharge, this energy could not be recovered in industrial applications and therefore might better be considered in the energy loss of the cyclone.

Capacity ratio expressed as feed gallons per minute divided by the square root of the cyclone energy loss in feet of fluid determined for the various runs was plotted against inlet diameter with parameters of overflow diameter in Fig 3a, and against overflow diameter with inlet diameter parameters in Fig 3b. Both are log-log plots. It will be observed that good straight parameter lines could be drawn for both cases, all of which were parallel for any one graph. Furthermore, this straight line relationship is valid for a ratio of overflow to inlet diameter of 0.6 to 2.0. This ratio more than covers the usual industrial cyclone design.

To correlate these findings with industrial data, test runs on the 10 in. Wilmington cyclone are included in Fig 3a and the 14 in. Kayford Driessen cone in Fig 3b. Lines parallel to the pure water parameters were drawn

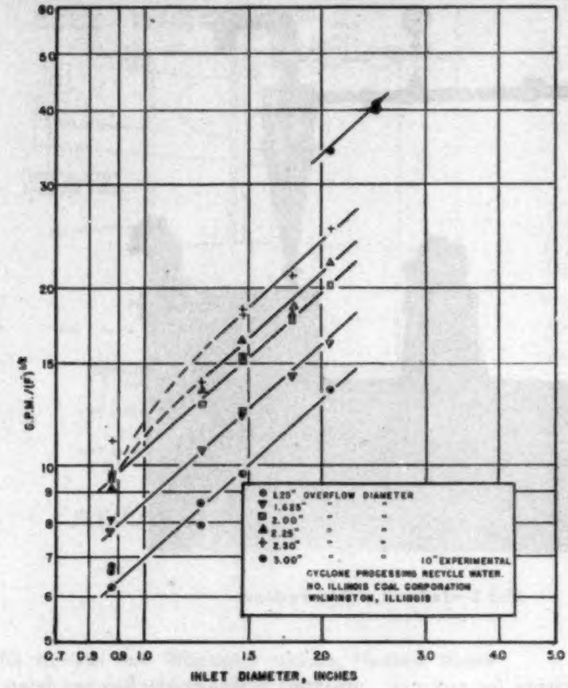

FIG 3a—Capacity ratio as a function of cyclone inlet diameter with constant overflow diameter parameter.

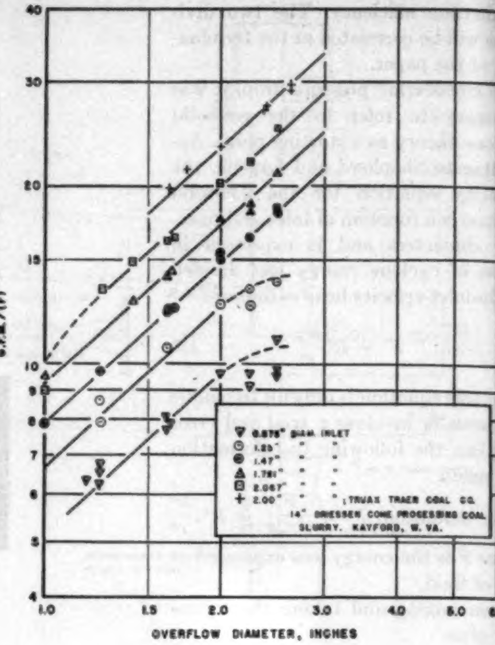

FIG 3b—Capacity ratio as a function of cyclone overflow diameter with constant inlet diameter parameter.

through the industrial data to indicate correlation. It will be observed that in both cases agreement was good.

The slope of Fig 3a which equals the exponent t is 0.89, while that of Fig 3b which equals the exponent s is 0.9. For convenience, the exponent on both terms was assumed as 0.9 which introduces a negligible error. Thus, Eq 6 can properly be applied to any liquid-solid cyclone within the designated overflow to inlet diameter ratio as

$$Q/\sqrt{F} = K(eb)^{0.9} \qquad [8]$$

The average K value for the 9 in. experimental cyclone determined from the straight line portion of the parameters was 5.61. The range of variation was 5.47 to 5.73, with an average deviation of 0.079 or 1.4 pct. For the 9 in. cyclone, then

$$Q/\sqrt{F} = 5.61\ (eb)^{0.9} \qquad [9]$$

At this point, it is interesting to note that the exponents m and n for the gas cyclone were both equal to 2. From Eq 6, therefore, s and t should each be equal to 1 for the gas-solid cyclone. The slight deviation for the liquid-solid cyclone can probably be explained by the different fluid characteristics.

To further illustrate the similarity, the K' value for the gas-solid cyclone was determined as 16.0. From Eq 6, K would therefore equal 4.93. This deviation from the 9 in. K of 5.61 can be attributed largely to minor design factors.

Eq 8 indicates the effect of inlet and overflow diameters and capacity on energy requirements. However, the variation of the K value for any cyclone must be determined, as well as the investigation of the remainder of the 10 variables listed at the beginning of the paper. For convenience, they will be considered individually in the given order.

Weight Percentage of Solids in Feed

Several runs were made with varying solid concentrations in the feed to observe any effect of solid concentration on energy loss. As the line slopes of the industrial data in Fig 3a and b indicated that solid concentration had no influence on nozzle diameter exponents, any alteration of Eq 9 for the 9 in. cyclone would be found in the K value.

In performing the solid runs, two different types of slurries were used, the first being various coal and refuse solids, and the second a silt and clay material with a close gravity range of 2.70 to 2.75. Assuming Eq 8, K values could be determined for the various runs. However, these values were obviously too high, which seemed incongruous, especially as the feed slurry became more concentrated. Upon observation of the character of the underflow during operation, it was observed that the vortex discharge was considerably more vigorous as the dilution of the solids increased. Thus, it was reasoned that the solids discharged in the underflow represented a negligible amount of energy loss, and therefore should be omitted from capacity ratio considerations. Theoretical principles further strengthen this assumption as cyclone energy loss is almost totally confined to loss of rotational kinetic energy in the inner spiral. As most underflow solids never reach the inner spiral, they should thus be excluded from energy calculations. The vortex discharge is maintained as long as the solid concentration is no more than about 55 pct. Accordingly, in calculating the capacity ratio for solid runs, the volume occupied by the underflow solids in a 55 pct slurry was subtracted from the feed rate in gallons per minute. These values were then plotted in Fig 4 as a function of solid feed concentration. It is apparent that the majority of values fell within experimental error of the water K value of 5.61.

In order to prove this method of calculating capacity ratios for solid runs is correct and has no deleterious effect on the diameter exponent of Eq 8, the industrial data on the 14 in. Driessen cone at Kayford was reworked on this basis. Table 1 is a compilation of these results. As the data had originally been plotted in Fig 3*a* based on the feed in gallons per minute, it was necessary to replot the data, using the corrected capacity ratio. This was done on log-log paper in Fig 5, and also includes the uncorrected data. A line of slope 0.9 was drawn for each set of data and it is apparent that the agreement is as good with the corrected method.

From the above discussion, it is evidently safe to assume that solid concentration will have no decreasing effect on the *K* value indicating that capacity efficiency is maintained.

Specific Gravity of Solids

From Fig 4, it can be observed that particle gravity has a small or negligible effect on *K* value. Coal and refuse slurries appeared to have slightly higher values than the heavier material in a few cases. However, it is believed that this influence is minor and can be ignored.

Separation Between Overflow and Conical Section

Because of the change in direction of the outer spiral at the base of the conical section, the placement of the overflow exit with reference to this point can be expected to have an effect on the capacity ratio. For the 9 in. cyclone, 3 and 6 in. cylindrical spacers, which could be inserted between the conical section and overflow point, were constructed. Capacity ratio tests with a parameter of constant overflow and one of constant inlet were made and results plotted in Fig 6*a* and *b*. Included in these log-log graphs are the same parameters obtained from Fig 3*a* and *b* for the 9 in. cyclone without spacers. From the 6 in. parameters of Fig 6*a* and *b*, it is apparent that a 6 to 8 pct increase in capacity ratio was obtained by its use. This probably results from the creation of a more gentle direction change at the base of the conical section when it is removed from the overflow point where undoubtedly other severe direction changes are occurring. Due to the lack of time, it was impossible to follow this trend further with

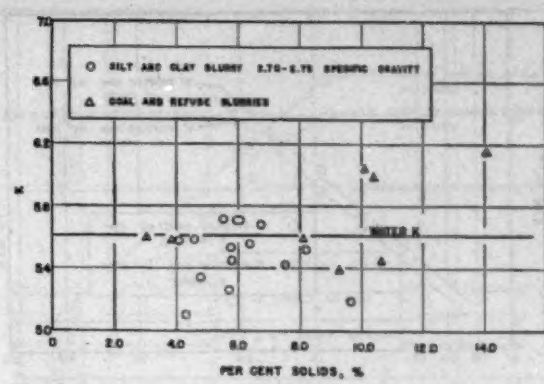

FIG 4—*K* value as a function of solid concentration, 9 in. cyclone.

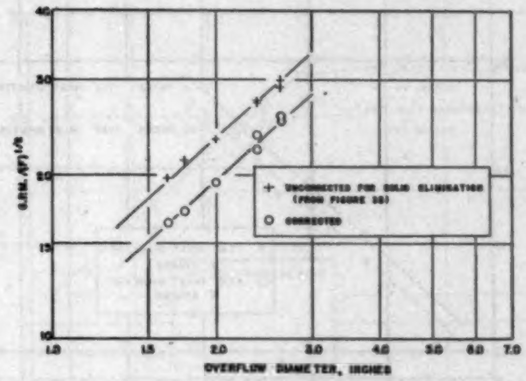

FIG 5—Corrected solid capacity ratio on 14 in. Driessen cone as a function of overflow diameter.

Table 1 . . . Test Runs on a 14 In. Driessen Cone, Truax-Traer Coal Co., Kayford, W. Va., Feed Slurry—Clean Coal Boot Overflow

Run No.	Diameter, In.		Line Pressure, Lb per Sq In. Gauge	Volume Rate, gpm			Volume, Pct To Underflow	Solids, Pct			Solids Rate, Lb per Min		
	Inlet	Overflow		Feed	Overflow	Underflow		Feed	Overflow	Underflow	Feed	Overflow	Underflow
1	2	2⅝	24.75	212.9	185.1	27.8	13.1	11.42	3.98	56.6	207.5	62.0	145.5
2	2	2⅜	25.25	203.4	174.8	28.6	14.1	11.72	3.98	53.4	204.7	58.5	146.2
3	2	2	26.0	173.6	135.1	38.5	22.2	14.50	4.59	46.0	217.2	52.1	165.1
4	2	1¾	26.25	158.8	109.7	49.1	31.0	15.18	4.40	37.9	209.1	41.0	168.1
5	2	1⅝	25.75	146.5	93.0	53.5	36.5	15.30	4.15	33.3	195.9	32.8	163.1
6	2	2⅝	25.75	222.2	191.0	31.2	14.0	15.12	6.90	58.3	295.0	113.0	182.0
7	2	2⅜	26.5	239.6	236.4	3.2	1.3	14.65	13.81	65.5	305.4	283.2	22.2
8	2	2⅜	26.5	204.2	167.2	37.0	18.1	17.3	7.40	58.5	309.8	106.1	203.7

Run No.	Pct of Total Solids in Underflow	Calculated Cyclone Energy Loss Ft of Feed Slurry	Capacity Ratio		Underflow Discharge Type	50 Pct Point Microns Equiv. Diam	Correlating Factor $(gpm)^{0.33}/(ab)^{0.33}$
			Uncorrected	Corrected			
1	70.2	54.0	29.0	25.2	Transition	47	5.64
2	71.4	55.0	27.4	23.6	Transition	46	5.84
3	76.0	55.6	23.2	19.4	Vortex	41	6.0
4	80.4	55.5	21.3	17.1	Vortex	40	6.25
5	83.3	54.8	19.8	16.0	Vortex	32	6.32
6	61.7	55.3	29.9	25.6	Transition	50	5.69
7	7.3	57.7	31.5	31.1	Overloaded, no hydrometer analysis		5.90
8	65.7	56.8	27.1	22.2	Transition	43	5.84

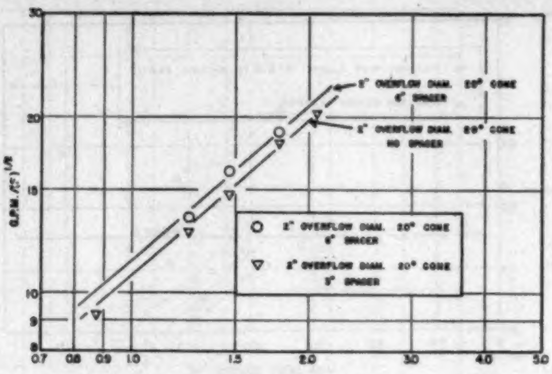

FIG 6*a*—Effect* of conical section separation on capacity ratio, 20° cone.

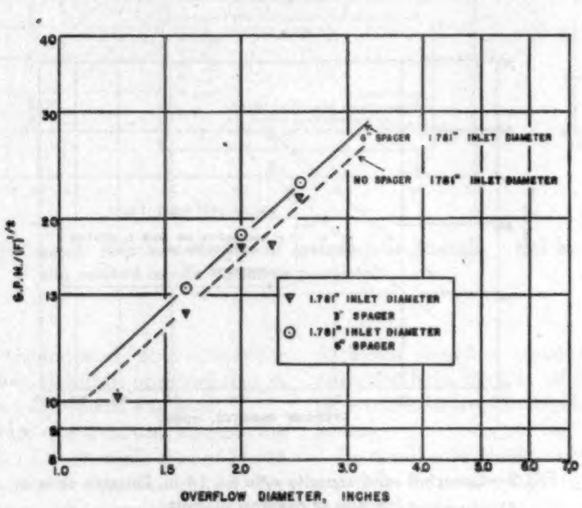

FIG 6*b*—Effect of overflow and conical section separation on capacity ratio.

Table 2 . . . Test Runs, 10 In. Experimental Cyclone, Northern Illinois Coal Corp., Wilmington, Ill., Feed Slurry—Recycle Water

Run No.	Diameter, In.		Line Pressure Lb per Sq. In. Gauge	Volume Rate, gpm			Volume Pct to Underflow	Solids, Pct			Pct of Total Solids in Underflow
	Inlet	Overflow		Feed	Overflow	Underflow		Feed	Overflow	Underflow	
1	2.067	3.067	20.0	229.7	220.5	9.2	4.0	12.5	9.75	59.4	25.4
2	2.067	3.067	19.9	227.3	219.0	8.3	3.7	13.4	11.22	58.2	20.1
3	2.469	3.067	20.75	272.0	260.0	12.0	4.3	12.4	9.7	56.6	25.8
4	2.469	3.067	20.75	272.4	265.5	6.9	2.5	7.6	6.2	49.9	21.2
5	2.469	3.067	22.0	242.8	234.0	8.8	3.6	10.0	7.8	57.6	20.0
6	2.469	3.067	23.4	280.5	268.0	12.5	4.5	8.5	6.31	46.2	29.5
7	2.469	3.067	23.1	295.8	282.0	13.8	4.7	4.3	3.16	25.1	30.4
8	2.469	3.067	21.2	282.2	262.0	22.2	7.15	11.7	8.70	45.4	31.7

Run No.	Calculated Cyclone Energy Loss Ft of Feed Slurry	Capacity Ratio		50 Pct Point Microns Equiv. Diam	Correlating Factor $(gpm)^{0.44}/(eb)^{0.48}$	Cone Included Angle	Overflow and Conical Section Spacing, In.
		Uncorrected	Corrected				
1	45.3	34.1	32.7	23	5.01	15	0
2	44.1	34.2	32.9	Undeterminable	5.00	45	20
3	42.8	41.5	39.7	26	4.94	15	0
4	43.6	41.2	40.2	33	4.94	45	10
5	46.4	35.6	32.9	35	4.66	45	0
6	48.9	40.1	39.0	No hydrometer analysis	5.04	15	0
7	48.4	42.5	41.7	No hydrometer analysis	5.15	15	0
8	44.0	40.7	40.1	29	5.05	15	0

larger spacers, but it is believed that relatively little, if any, increase would have been experienced.

As a corollary of this, data was obtained on the experimental 10 in. cyclone at Wilmington, Ill., a tabulation of which appears in Table 2. A 45° insert cone used during some of the tests could be set at any desired distance from the overflow point. It will be observed that a 16 pct increase in capacity ratio and K value was obtained when this distance was changed from 0 to 10 in. No further increase was noted with a larger separation.

Cyclone Included Angle

Due to the more severe direction change, it was believed that capacity ratio and K value would decrease with an increase in included angle. A 30° cone was constructed for the 9 in. cyclone and capacity ratio tests performed at a constant inlet diameter, and also one at constant overflow. Results are plotted on log-log paper in Fig 7*a* and *b* and include the same parameter using the 20° cone with no spacer obtained from Fig 3*a* and *b*. A 10 pct decrease in capacity ratio was experienced with the 30° cone with no spacer as compared to the 20° cone. However, values increased as before as spacers were inserted until they slightly exceeded those of the 20° cone with no spacer.

This phenomenon can also be observed in Table 2 where the 15° cone exhibited a 16 pct larger capacity ratio than the 45° cone with no separation between overflow and conical section. However, when the spacing was sufficient, capacity ratios were equal. This also yields the important indication that a 15° cone appears to give the maximum capacity ratio, as the 45° cone could never exceed this value regardless of the separation between overflow and conical section, other dimensions being equal.

Volume Percentage Reporting to the Underflow

Depending on the solid concentration, different volume percentages of the original feed may be discharged to the underflow. To determine this effect, several water runs were made with varying volume distributions between overflow and underflow. The calculated capacity ratios were then compared with those of similar parameters

in Fig 3*a* and *b*. A summary of these tests, together with the calculated capacity ratios and their percentage of deviation from the low volume split ratios will be found in Table 3.

From the percentage of deviation values given in Table 3, it would appear that volume split has only a slight effect on capacity ratio, the majority of runs showing a very small positive increase. Therefore, it seems reasonable to expect Eq 6 to be valid within 5 pct, regardless of the volume split. This is logical when one considers that the vortex underflow stream issues with a very vigorous spray representing a high rotational kinetic energy. The energy must be entirely lost if the vortex discharge is to be maintained. It appears, therefore, that the energy recovered by allowing a lesser overflow is almost completely offset by the energy leaving as rotational kinetic energy in the increased underflow stream.

Industrial data again tended to show the same phenomenon. From the Table 1 tabulation of runs made on the 14 in. Driessen cone at Kayford, W. Va., it will be seen that volume split to the underflow varied from 14.0 to 36.5 pct for the underflow discharge. Yet, it is apparent from Fig 5 that the capacity ratio line was unaffected.

Cyclone Diameter

With the gas-solid cyclones, wall friction was found to be negligible, and consequently cyclone diameter had no effect on the *K* value.[7,8] To determine the importance of this variable with the liquid-solid cyclone, a 7 in. cyclone on hand, and a newly constructed 3 in. cyclone were used. Both possessed included angles of 20°, and similar spacings between overflow point and conical section to that of the 9 in. cone without spacers. Water tests on these cyclones yielded the following *K* values, assuming Eq 8 to be valid: 3 in. cyclone, 5.55; 7 in. cyclone, 5.20.

These compare very favorably with the 9 in. cyclone *K* value of 5.61. Solid runs on the smaller cyclones also yielded comparative values. As the 14 in. Driessen cone was similar in construction to the experimental cyclones, its *K* value is also of importance. Referring to Fig 5, the *K* value was determined from the line of the corrected data as 5.57. From these results it can be seen that cyclone diameter actually has a negligible effect on *K* value and therefore an average of the 4 cyclone diameter values would be appropriate. This would then yield the following equation which would be valid for any cyclone of 20° included angle with less than 1 in. separation between overflow and conical section.

$$\frac{\text{gpm}}{\sqrt{F}} = 5.48\,(cb)^{0.9} \qquad [10]$$

It should be emphasized, at this point, that the gallons per minute (gpm) expressed in this equation is the corrected value as explained in the previous discussion on the effect of solid concentration.

The 10 in. cyclone at Wilmington, when used with a 15° cone, accordingly possessed a higher *K* value of 6.38. Thus, the equation for the 15° cone would be

$$\frac{\text{gpm}}{\sqrt{F}} = 6.38\,(cb)^{0.9} \qquad [11]$$

Further interpretations on the application of these equations when used on cyclones of varying design will be

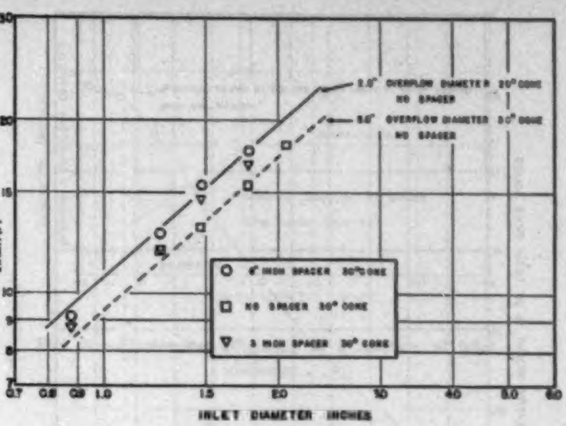

FIG 7*a*—Effect of cyclone included angle on capacity ratio.

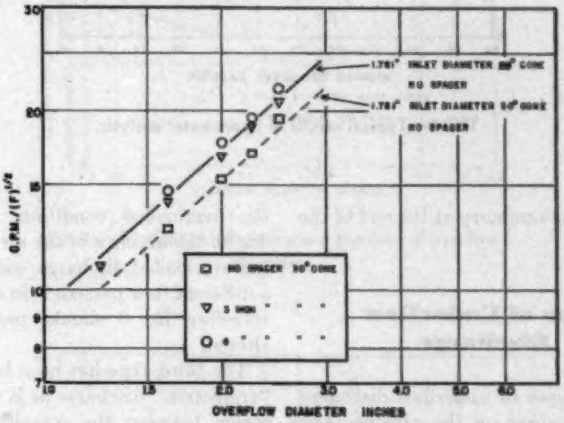

FIG 7*b*—Effect of cyclone included angle on capacity ratio.

Table 3 . . . Effect of Volume Distribution on Capacity Ratio, 9 In. Cyclone—Water Runs

Run No.	Nozzle Diameter, In.		Volume Pct to Underflow	$\frac{\text{gpm}}{(F)^{1/2}}$	Pct Deviation from Low Volume Split
	Inlet	Overflow			
14	1.25	1.0	28.8	6.93	+4.68
16	1.25	1.406	12.4	9.09	+1.0
19	1.25	1.1875	18.6	7.99	+3.23
26	1.47	1.	26.1	7.86	0
32	2.067	1.406	8.7	13.97	−3.66
94	1.25	1.25	16.7	8.64	+6.53
110	0.875	1.25	17.9	6.22	0
127	1.781	1.25	15.2	10.19	−9.02
131	1.47	1.25	28.1	9.7	0
142	1.47	1.25	27.2	9.02	0
151	0.875	1.25	21.5	6.55	+5.3
176	1.781	1.25	8.6	10.38	−7.73
208	1.781	2.00	8.43	18.0	+4.65
269	1.781	1.625	13.8	14.7	+3.16
271	1.781	2.00	8.8	17.61	+2.38
277	1.781	2.00	8.1	17.7	+2.91
279	1.47	2.00	8.6	15.45	+4.21
281	1.25	2.00	9.1	12.73	+1.84

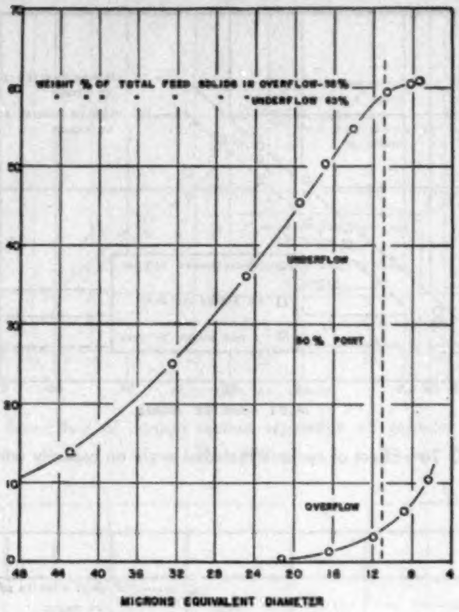

FIG 8—Typical results of hydrometer analysis.

given in the summary at the end of the paper.

Type of Underflow Discharge

Three types of underflow discharge can be obtained on the cyclone. The first is the vortex type which is characterized by a spiral spray with an accompanying air core. The air core is maintained by a vacuum created by the cyclone flow pattern. The second type is commonly designated as overloaded and consists of a very sluggish discharge with no spiral characteristics. Solid concentration is always higher than 60 pct and there is no air entering the cyclone. The condition is brought about by the fact that more ejectable solids are present in the feed than can issue in the underflow. Accordingly, a bed of solids is built up in the apex of the cone and a considerable quantity of solids is carried out in the overflow stream.

No observations of any extent were made with the overloaded condition as all tests to date indicate that solid elimination efficiency is severely injured with this phenomenon in effect. Examples of this inefficiency will be given in more detail in the section on solid elimination. The few solid tests made exhibited an appreciable increase in K value, assuming Eq 8 to hold for the overloaded condition. However, due to the absence of the air core with the overloaded discharge, undoubtedly a different flow pattern is in effect, and therefore Eq 8 should probably be altered.

The third type has been labeled the "transition" discharge as it marks the region between the completely overloaded and complete vortex conditions. It is characterized by a slightly less vigorous vortex than the complete vortex discharge and underflow solid concentration closely approaches that of the overloaded type. Capacity ratio tests performed with this discharge indicated only minor deviations from the established capacity ratio equations. This was correlated by industrial data on the 14 in. Driessen cone.

Yancey and Geer obtained a discharge that appeared to compromise the overloaded and complete vortex conditions.[5] A sausage type of discharge that issued in a rotating fashion was experienced on certain coal slurries with a 5 in. cyclone. No such underflow could be obtained in this work, and possibly the particular size consistency and different cyclone design they were operating with may have brought about the condition.

Besides the big advantage of high solid efficiency, the vortex discharge is much simpler to operate. With the overloaded and transition type, very small changes in feed concentration can bring about a very large loss of solids to the overflow. This is not the case with the vortex type. Illustrations to be given in later discussions will indicate that the very large increase in solid elimination efficiency with the vortex type of discharge considerably more than offsets any small saving in energy requirements with the overloaded discharge.

Solid Elimination Efficiency

In operation, the fraction of solids eliminated from a feed slurry to a liquid-solid cyclone is probably more important than the accompanying energy loss. Operating costs of the cyclone are very small and many times little could be saved by decreasing pressure drop. In contrast, by designing a cyclone to extract a finer particle size there is much to be gained as added revenue in the case of fine coal or decreased operating cost when working with refuse slurries.

The most common method of measuring extraction efficiency is the determination of the 50 pct point. This is represented by the particle size that reports 50 pct to the overflow and 50 pct to the underflow. It also quite accurately portrays the limit of extraction efficiency as very little material of similar specific gravity but coarser in nature will be found in the overflow stream and by the same token only a relatively small amount of particles finer than this dimension will report to the underflow. The phenomenon is pictured in Fig 8, an analysis of a test run on the 9 in. cyclone illustrating the size distribution of the feed solids between overflow and underflow. A vertical line has been drawn at the 50 pct point (location on curves where slopes are equal) to indicate the small amount of material present on one side of this line for either stream.

In previous work, many runs were made with coal and refuse slurries in an attempt to obtain fundamental data.[4] However, this procedure had to be abandoned as the large variation in particle gravity found in this material prohibited the determination of the 50 pct point with any degree of accuracy. Naturally, the elimination efficiency will be a function of solid specific gravity and as solids in these slurries range in gravity from 1.2 to 5.0, it follows that actually a continuous curve of 50 pct point as a function of particle gravity is in effect.

To eliminate this error, it was de-

cided to standardize the tests upon a material that possessed a very close gravity range. This eliminated the use of coal as refuse material of higher gravity would be liberated upon degradation. A silt and clay material of gravity range 2.70 to 2.75 was finally obtained from a local deposit.

Because the 50 pct point for the liquid-solid cyclone is well below the 200 mesh size, screen analyses are of no use in its accurate determination. The hydrometer method of Casagrande, widely used in soil analysis, offered the best solution to this situation.[10] As the analysis is based upon settling velocities, the particle sizes determined are expressed as equivalent diameters—the diameter of a sphere of similar specific gravity settling at the same terminal velocity as the particle in question. Although this may not correspond to the actual particle dimension, it yields a size which depicts the nature of the particle under actual operating conditions. From rate samples taken for each run, it was then possible to determine the 50 pct point. A typical analysis has been plotted on Fig 8 on a considerably reduced scale.

Fundamental Considerations

In attacking the problem, it was felt that the same three variables of major significance with regard to energy loss would be of similar importance in solid elimination efficiency. As inlet nozzle diameter decreases, entrance velocity increases for a constant throughput. Due to the spiral flow pattern, tangential velocity increases inversely with cyclone radius. Therefore it would seem proper to assume an increasing critical centrifugal force as inlet diameter decreased for a fixed capacity. By the same consideration, centrifugal force should also vary directly with volume throughput. Finally, with regard to the overflow nozzle, it is necessary to refer again to the gas-solid cyclone theory.[7,8,11] It was found that the location of maximum centrifugal force occurred at a critical radius approximately equal to that of the overflow tube. By decreasing this radius, centrifugal force should be increased.

To determine the extent of these various factors, elimination efficiency tests were made with the 9 in. cyclone maintaining two of the three variables constant during any one set of runs. The elimination efficiency was plotted against the variable factor on log-log

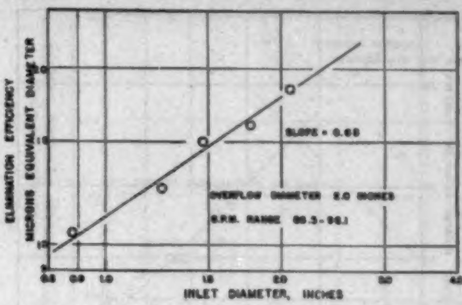

FIG 9a—Elimination efficiency as a function of inlet diameter.

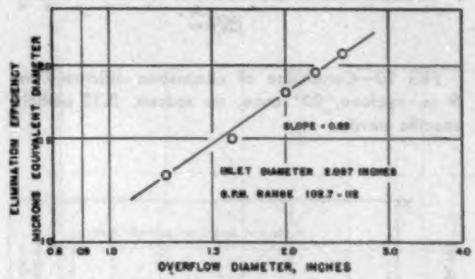

FIG 9b—Elimination efficiency as a function of overflow diameter.

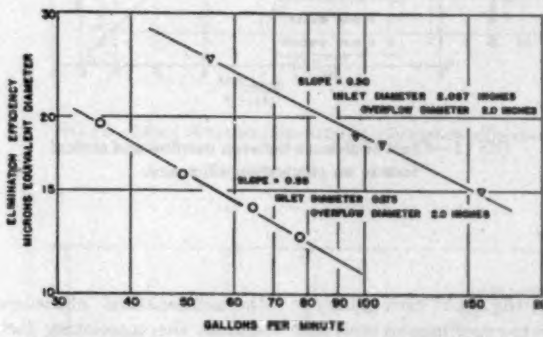

FIG 9c—Elimination efficiency as a function of cyclone capacity.

paper to ascertain if the effects were exponential functions. Fig 9a indicates elimination efficiency as a function of inlet diameter. During these tests, overflow diameter was 2 in. and the feed rate maintained at 88.5 to 96.1 gpm. Considering that experimental error probably limits determination of the 50 pct point to an accuracy of 1 micron, it appears that the inlet diameter either is or closely approximates an exponential function. The slope of the average line drawn in Fig 9a is 0.68 and equals the exponent on the inlet diameter term.

Fig 9b plots elimination efficiency vs. overflow diameter during which time the inlet nozzle was 2.067 in. and slurry rate varied between 102.7 and 112.0 gpm. An excellent straight line relationship was obtained with the slope being 0.68 as in Fig 9a.

The factor of feed rate is investigated in Fig 9c where two sets of runs are plotted against gallons per minute. Straight lines of slopes −0.50 and −0.56

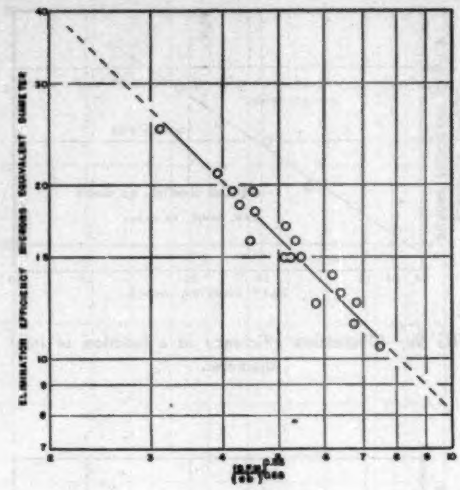

FIG 10—Correlation of elimination efficiency for 9 in. cyclone, 20° cone, no spacers, 2.73 particle specific gravity.

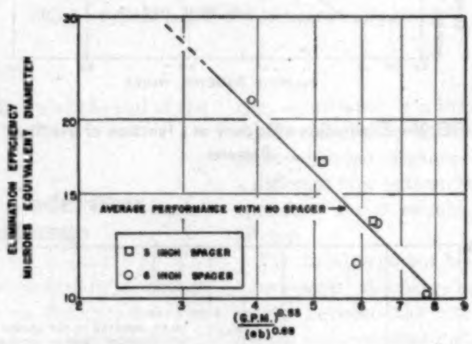

FIG 11—Effect of distance between overflow and conical section on elimination efficiency.

are observed; the slight discrepancy is probably due to experimental error and therefore the average value of −0.53 was used in later work.

From the above results, elimination efficiency must be a function of the three expressed variables raised to the proper exponent. Due to the success of the equation developed for energy loss, a correlation was attempted on the basis of multiplication of the three variables. In order to obtain a small correlating factor greater than one, the reciprocal of the number indicated by the exponents was used. Thus, the correlating factor was:

$$\frac{(gpm)^{0.53}}{(eb)^{0.68}} \qquad [12]$$

Several further runs were made and the elimination efficiencies plotted against the correlating factor on log-log paper in Fig 10. If no other factors are of significant importance exclusive of those which will be discussed in later sections and which were held constant during these runs, it should be possible to draw a line of slope −1 through the results. This was done as indicated in Fig 10 and an observed good agreement does exist. Of the 18 points, only 3 deviate by more than 1 micron and of these, only one is displaced from the line by 2 microns. The equation of the indicated line is:

$$\text{elimination efficiency, microns} = \frac{81\ (eb)^{0.68}}{(gpm)^{0.53}} \qquad [13]$$

It is believed that the range for the 9 in. cyclone has been quite thoroughly explored as gallons per minute varied from 35.5 to 150.6, inlet diameter from 0.875 to 2.067 in., and overflow diameter from 1.25 to 2.50 in.

No similar correlation could be obtained for elimination efficiency with industrial data as indicated in Tables 1 and 2. Two sources are responsible for this situation. First it was impossible to determine the 50 pct point with sufficient accuracy as it appeared to exist over a wide range instead of at an isolated size as with the standard material. This is caused by the wide variation in particle gravity present. Secondly, these samples were taken on many different days and times, undoubtedly large variations in solid consist and quality existed. However, it is obvious from Tables 1 and 2 that elimination efficiency does vary with the correlating factor in the same direction as the test material. Of particular interest is the quantitative efficiency of extraction experienced with the cyclone. Little difficulty was encountered in obtaining a 50 pct point of 15 to 17 microns with a throughput of 150 gpm at 20 to 25 psi pressure. This left in suspension only very fine particles of a nonabrasive character and a water that was suitable for further process work. This represents a capacity of 340 gpm per sq ft area for the 9 in. cyclone. If increased elimination efficiency is desirable, smaller nozzles can be used at higher pressures.

Separation Between Overflow and Conical Section

The distance between the conical section and overflow exerted a definite effect upon the capacity ratio of the cyclone. To check this factor with regard to elimination efficiency, runs were made with the 3 and 6 in. spacers in place. Results have been plotted on log-log paper in Fig 11. Also included is the line drawn in Fig 10 representing the average elimination efficiency performance without spacers. Spacer points were either within 1 micron of the line or well below it in all cases and thus operation can be considered equal to the former method using no spacers. The same phenomenon was observed with industrial data on the 10 in. cyclone. Run 4 of Table 2 which possessed a 10 in. spacing between overflow and conical section exhibits a lower 50 pct point and a higher solid extraction than run 5 where there was no separa-

tion present. This is especially significant as a higher capacity ratio is also obtained with the separation. In future cyclone design, advantage should be taken of this characteristic by allowing 6 to 10 in. between overflow and conical section.

Cyclone Included Angle

Three solid runs were made using the 30° cone to observe the effect of cyclone included angle on elimination efficiency. In these tests, nozzle diameters and capacity were varied in order to yield a good range of the correlating factor. Results are plotted on log-log paper on Fig 12 and are compared with the average performance line obtained with the 20° cone. An appreciable increase in the 50 pct point is readily apparent indicating that included angle should be kept to a minimum.

A similar effect is evident in the industrial data for the 10 in. cyclone of Table 2. Substantial increases in the 50 pct point and corresponding decreases in percentage of total solids eliminated were experienced when the insert cone was changed from 15 to 45°.

Cyclone Diameter

As centrifugal force is inversely proportional to the radius of curvature, investigation of cyclone diameter is mandatory for a thorough examination of elimination efficiency. Solid runs were accordingly performed on 3 and 7 in. cyclones. As the inlet and overflow diameters were fixed it was necessary to vary the volume throughput in order to obtain different values of the correlating factor. Resultant points are indicated on Fig 13 along with the average performance line of the 9 in. cyclone. All values lay within 1 micron of the average line or its extension indicating that cyclone diameter has a negligible effect on elimination efficiency as predicted by the 50 pct point. Furthermore the 3 in. cyclone points always lay above the average line while those of the 7 in. were below, a second indication of the unimportance of cyclone diameter.

Percentage of Feed Volume Discharged to Underflow

Theoretical considerations naturally indicate a decreasing 50 pct point as volume split to the underflow increases. As higher volume fractions report to

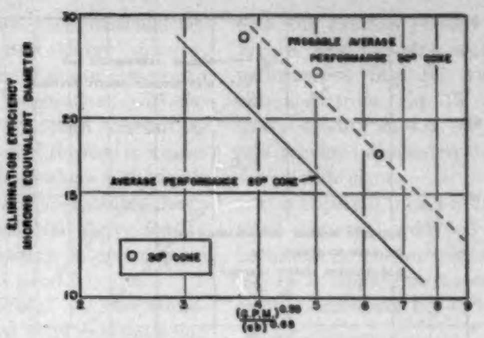

FIG 12—Effect of cyclone included angle on elimination efficiency.

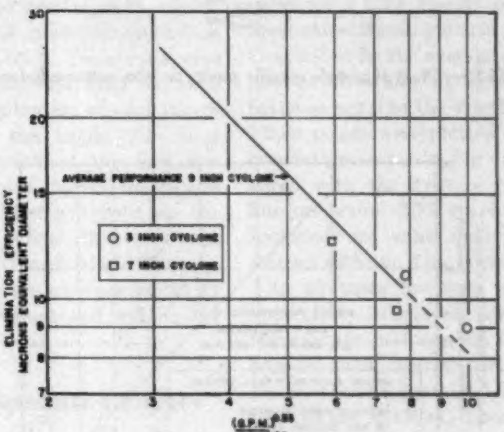

FIG 13—Effect of cyclone diameter on elimination efficiency.

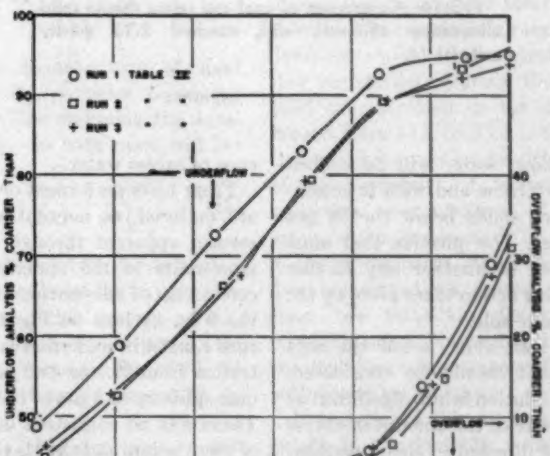

FIG 14—Size analyses of runs 1, 2, and 3 of Table 4.

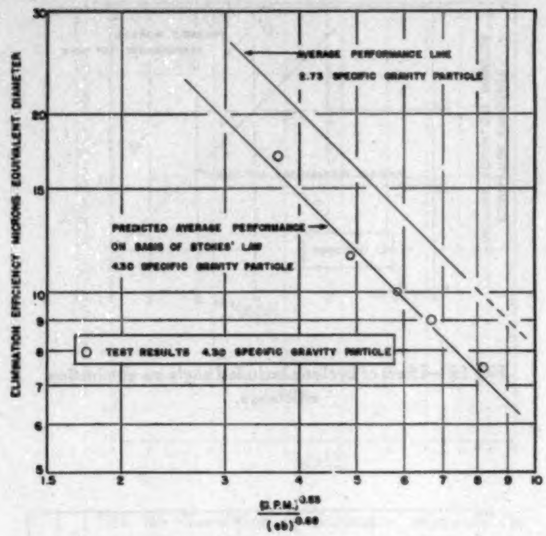

FIG 15—Effect of particle specific gravity on elimination efficiency.

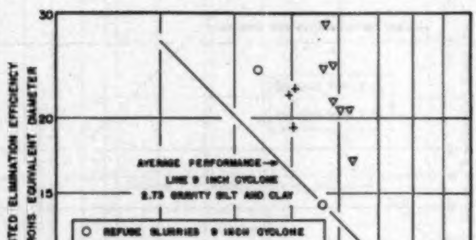

FIG 16—Comparison of coal and refuse slurries solid elimination efficiency with standard 2.73 gravity material.

the underflow, water will be robbed from the overflow and with it accompanying fine solids below the 50 pct point in size. The question that must be answered is whether any further concentrating action takes place by the higher volume split.

Volume split alone is not the only criterion that should be considered. Underflow dilution is also significant as it is a measure of the amount of excess water being directed to the underflow. For coal and refuse slurries, approximately 50 to 55 pct solids seems to be appropriate underflow concentration to maintain a vortex discharge. Any lesser concentration indicates the presence of excess water.

From tests performed on the standard material, no concentrating action seemed apparent through higher volume splits to the underflow. In the correlation of elimination efficiency for the 9 in. cyclone on Fig 10, 7 of the runs ranged in underflow solid concentration from 24.1 to 49.0 pct with volume splits up to 8 pct to the underflow. There was no consistent displacement of these points and they lay both above and below the average performance line for the 9 in. cyclone.

To observe the effect under more severe conditions, three runs were made at a constant inlet diameter of 1.47 in. and overflow diameter of 1.625 in. Throughputs were held to a range of 112.1 to 118.7 gpm. During the first run, volume discharge to the underflow was maintained at a normal value to yield a high solid concentration. In the later runs, volume split to the underflow was severely increased resulting in a large dilution of the discharged solids. The results obtained are shown in Table 4.

Table 4 . . . Effect of Volume Split on Solid Elimination Efficiency

Run No.	Feed, gpm	Volume Pct to Underflow	Underflow Solid Concentration Weight, Pct	$\frac{(gpm)^{0.55}}{(eb)^{0.68}}$	50 Pct Point, Microns
1	112.1	5.6	59.6	6.75	11.5
2	118.7	12.5	36.6	6.94	10.5
3	113.3	15.8	35.5	6.77	10.25

The 50 pct points exhibited only a minor decrease with the increased volume splits indicating that no further concentrating action was taking place. Thus, the additional water directed to the underflow contained only the weight percentage of solids similar to that found in the overflow. Further proof of this is offered in Fig 14 where size analyses of the two streams are graphically portrayed. It will be observed that overflow size distribution experienced no appreciable change in consist while the underflow stream contained slightly greater quantities of solids below 11.5 microns for runs 2 and 3. If greater concentration was taking place, the overflow curves would have shown a general displacement towards the finer sizes for the later runs. A logical conclusion is that dilution of underflow solids beyond 45 to 50 pct offers no further assistance in the concentration of the feed solids. This appears theoretically feasible when one considers that no greater centrifugal force occurs with high volume splits to the underflow. Therefore increased concentrating action cannot be expected.

Type of Underflow Discharge

The vortex underflow is universally conceded to be superior to the overloaded discharge in regard to elimination efficiency.[5,6] When an overloaded discharge is in effect, the underflow nozzle is operating completely full of liquid and solids preventing the formation of an air core necessary for spiral

action. This results in a "pile-up" of solids at the apex of the cone and appreciable quantities are carried out in the overflow stream.

Perhaps the most striking demonstration of this inefficiency will be found in the data on the 14 in. Driessen cone at Kayford, W. Va., given in Table 1. Runs 6 and 7 were made under practically the same conditions except that an overloaded discharge was present in the latter case. It will be observed that 61.7 pct of the total feed solids were eliminated to the underflow in run 6 at a concentration of 58.3 pct. By contrast, run 7 eliminated only 7.3 pct of the total solids at a concentration of 65.5 pct. It is apparent that efficiency was very severely penalized while obtaining only a small increase in underflow solid concentration. Although pure overloaded discharge runs were not made with the 9 in. cyclone in this study due to the obvious inefficiency, previous tests had been performed with the 7 in. cyclone and were reported in an earlier paper.[6] Though the results were not as striking as the above case, all such tests indicated a serious injury to solid elimination.

The "sausage" discharge of Yancey and Geer could not be obtained in these studies due either to size consist or cyclone design.[5] However, something approximating this condition was obtained in certain runs wherein a very high underflow solid concentration up to 65 pct was experienced with a transition discharge. In these cases the 50 pct point was found to be approximately 25 pct above the pure vortex discharge with a corresponding injury to total solids eliminated. As almost the entire solids processed were below 200 mesh, the percentage of total solids rejected would have been higher if coarser material had been present. At the same time, from experiences encountered on the 14 in. Driessen cone it was felt that this compromise condition would have been very hard to maintain with the larger solids.

Weight Percentage of Solids in Feed

When the cyclone operates on slurries containing up to 15 pct solids, the factor of slurry weight will be of relatively minor importance. Specific densities of such feeds will be no greater than 1.10 in extreme cases. Furthermore, the critical density effecting the elimination efficiency will probably be closer to that of the overflow stream. Thus the difference between particle and slurry density, which is naturally of major concern in any liquid-solid separation, will decrease only a very small amount as solid concentration of the feed increases up to 15 pct. The cyclone will handle considerably more concentrated feeds but one must expect that slurry density will be of increasing importance in raising the 50 pct point.

In tests performed on the standard material, feed solid concentration ranged from 4.07 to 9.65 pct. In the elimination efficiency correlation of Fig 10, no consistent effect of solid concentration was apparent. As further indication of this, runs 6 and 7 on the 10 in. cyclone at Wilmington yielded almost identical results with regard to percentage of solids eliminated as exhibited in Table 2. These runs were made within one-half hour of each other after termination of coal movement through the tipple. The feed solid concentration of the first run was almost double that of the second and yet the difference between the percentage of solids eliminated was negligible. This was considered significant due to the existing similarity between size consist and quality for the two runs.

Particle Specific Gravity

As the particle specific gravity increases, still finer solids should be ejected to the underflow. Considering Stokes' law which applies to solids below the 200 mesh size,

$$w = \frac{(\rho_s - \rho)62.4gX^2}{18\mu} \qquad [14]$$

Therefore the diameter ratio of equal settling velocity particles possessing different gravities assuming the same slurry viscosity in both cases will be:

$$\frac{X_1}{X_2} = \left[\frac{\rho_{s2} - \rho_2}{\rho_{s1} - \rho_1}\right]^{1/2} \qquad [15]$$

If Stokes' law is valid for the prediction of cyclone 50 pct point for any particle gravity, then specific gravity parameter lines could be drawn parallel to the average performance line of Fig 10 and displaced from it according to Eq 15.

To validate this statement, a native ground barytes (barium sulphate, $BaSO_4$) of 4.30 sp gr was obtained for test purposes. Resulting elimination efficiency was plotted against the correlating factor on Fig 15 together with the average performance line of Fig 10. Also included is the predicted performance line for this material obtained from Eq 15 assuming a slurry density of 1.0. As pointed out in a previous discussion this will cause a negligible error.

It is apparent from Fig 15 that agreement between predicted and actual performance is excellent indicating Eq 15 is applicable to cyclone operation. Combining Eq 13 and 15 then,

elimination efficiency, microns

$$= 81\,\frac{(eb)^{0.66}}{(\text{gpm})^{0.54}}\left[\frac{2.73 - 1.0}{\rho_s - \rho}\right]^{0.5} \qquad [16]$$

Elimination efficiency data of Tables 1 and 2 were adjusted by use of Eq 15 to indicate the corresponding 50 pct point for a 2.73 gravity material. In these calculations, particle gravity was assumed to be the average of the overflow solids while slurry weight was taken as equal to the overflow density. These points were plotted against the correlating factor in Fig 16 and compared with the average performance line on actual 2.73 gravity material. Included are runs made on refuse slurries with the 9 in. cyclone.

In all cases but one, results were appreciably displaced upward from the average performance line. As the recycle water slurry used with the 10 in. cyclone contained large quantities of silt and clay, it was similar in nature to refuse material. For this type of slurry, an average performance line would appear to be about 25 to 30 pct higher than the standard line. Coal slurries of the 14 in. Driessen cone were higher but particular conditions surrounding the tests indicate that the four runs showing the greatest deviation should not be considered in this correlation. During these runs, solid concentration in the underflow ranged from 53.4 to 58.5 pct. Due to the very light average particle gravity of approximately 1.4, a more dilute underflow concentration of 50 pct solids or less is necessary to maintain a vortex discharge. With the underflow concentrations present in these runs, the transition discharge was instead in effect. Neglecting these runs, the deviation compares more favorably with the refuse slurries.

It is believed this deviation is due chiefly to the inability to accurately determine the 50 pct point. In the hydrometer analysis, an average solid specific gravity must be assumed and thus heavier materials present tend to increase the 50 pct size.

In spite of this error, the hydrometer method probably represents the best solution to the problem of size determination in the minus 200 mesh fraction of large gravity range particles. It offers a rapid and easy technique which is as accurate as any other procedure for this application. When predicting the percentage of total solids that could be eliminated by the cyclone for a particular slurry upon which a hydrometer analysis has been performed, a safety factor of 30 pct should accordingly be used in the determination of the 50 pct point by Eq 16.

Summary and Conclusions

Tests performed on the cyclone have proved it to be a simple and economic means for the elimination or recovery of fine solids from liquids in a sufficiently concentrated form so they may be further handled by ordinary equipment. Particles down to 9 and 10 microns have been eliminated from slurries. This dimension generally marks the bottom of the silt range and the top of the clay region indicating the cyclone's possibilities in not only the saving of fine coal but also the "cleaning-up" of water for reuse. In addition, operation is simple, initial cost is low, no moving parts are involved, and capacities up to approximately 350 gpm per sq ft of area can be obtained.

The following design features should be incorporated into a cyclone in order that solid elimination will be a maximum and energy requirements per feed gallon a minimum.

1. Maintain included angle of cone at minimum, preferably 15 or 20°.
2. Allow 6 to 10 in. between overflow point and conical section.
3. Underflow nozzle diameter should be large enough to permit a vigorous vortex discharge. This will be characterized by the presence of a vacuum at the underflow with a solid discharge concentration of 50 to 55 pct for refuse slurries and 50 pct or less for fine coal.

In calculating either the energy requirements or capacity of a cyclone, a formula of the type of Eq 8 is applicable. The gallons per minute used in the equation will be equal to the total feed rate minus the volume occupied by the ejectable solids in a 55 pct slurry. Eq 10 is applicable for a 20° included angle cyclone with less than 1 in. separation between overflow and conical section. If 6 in. or more separation is provided, the K value may be increased 6 to 8 pct and the expression will be valid for any cyclone with included angle of 20° or greater. Eq 11 may be used for any 15° cyclone.

The 50 pct point for any slurry may be predicted by use of Eq 16, using a safety factor of 30 pct in case a large particle gravity range is involved. The percentage of total solids that may be eliminated can finally be calculated from a screen analysis plus a hydrometer test on the minus 200 mesh fraction. All material coarser than the 50 pct point may be considered as ejectable.

In constructing the cyclone it is recommended that special heat treated alloys be used for certain parts in order to retard the rate of wear at critical points. All three nozzles, especially the underflow, are subject to abrasion and flanged parts should be provided at these locations in cyclone design. Nitriding of special alloys would probably offer the best solution to increased operating life.

Acknowledgments

The investigation was conducted in the Chemical Engineering laboratories of Northwestern University. Special acknowledgments are due Mr. R. L. Sutherland of the Truax-Traer Coal Co. and Messrs. James Jones and Melbourne McKee of the Northern Illinois Coal Corp. for their suggestions and cooperation in the study. The author also wishes to thank their respective companies for the opportunity of obtaining valuable test data. Finally, the following Northwestern University students have greatly aided the project by their help: George Andrae, Jerome Blau, John Graves, George Jandacek, Robert Piros, Arthur Robertson, Benjamin Schmetterer, Robert Slifer and Hubert Zaremba.

Nomenclature

b = inlet nozzle diameter, in.
e = overflow nozzle diameter, in.
F = cyclone energy loss, feet of fluid.
F' = gas cyclone energy loss expressed as feet of fluid flowing divided by inlet velocity head.
g = acceleration due to gravity, 32.2 ft per sec squared.
K = capacity ratio proportionality constant $= \frac{Q/\sqrt{F}}{(eb)^{0.9}}$
K' = gas cyclone proportionality constant $= F' + (b/e)^2$
m = gas cyclone inlet diameter exponent = 2.0.
n = gas cyclone overflow diameter exponent = 2.0.
Q = gpm = gallons per minute of feed slurry (corrected as explained in case of capacity ratio determination).
s = liquid cyclone overflow diameter exponent, capacity ratio equation.
t = liquid cyclone inlet diameter exponent, capacity ratio equation.
v_i = inlet velocity, ft per sec.
w = settling velocity of particle, ft per sec.
X = diameter of particle, ft.
ρ = specific gravity of slurry, g per cc.
ρ_s = specific gravity of solid, g per cc.
μ = viscosity, lb per ft-sec.

References

1. M. G. Driessen: Cleaning of Coal by Heavy Liquids. *Inst. of Fuel Jnl.* (1939) **12**, 327–341.
2. M. G. Driessen: The Use of Centrifugal Force for Cleaning Fine Coal in Heavy Liquids and Suspensions with Special Reference to the Cyclone Washer. *Inst. of Fuel Jnl.* (1945) **19**, (12) 33–45.
3. M. G. Driessen: The Use of Hydraulic Cyclones in Thickeners and Washers in Modern Coal Preparation. *Coal Tech.* TP 2135 (Aug. 1947); *Trans.* AIME (1948) **177**, 240.
4. J. W. Hyer: Heavy-density Separation—A Review of its Literature. *Quarterly*, Colo. School of Mines (1948) **43**, (1), 36–42.
5. H. F. Yancey and M. R. Geer: The Cyclone as a Thickener of Coal Slurry. *Coal Tech.* TP 2351 (Feb. 1948); *Trans.* AIME (1948) **177**, 262.
6. D. A. Dahlstrom and R. W. Maeser: Discussion entitled, Cyclone Elimination of Contaminating Solids from Process Water. *Coal Tech.* TP 2471, p. 13 (Nov. 1948); *Trans.* AIME (1948) 177, 277.
7. C. B. Shepherd and C. E. Lapple: Flow Pattern and Pressure Drop in Cyclone Dust Collectors. *Ind. and Eng. Chem.* (1939) **31**, 972–984.
8. C. B. Shepherd and C. E. Lapple: Flow Pattern and Pressure Drop in Cyclone Dust Collectors, Cyclone Without Inlet Vane. *Ind. and Eng. Chem.* (1940) **32**, 1246–1248.
9. C. B. Shepherd and C. E. Lapple: Calculation of Particle Trajectories. *Ind. and Eng. Chem.* (1940) **32**, 605–617.
10. A. Casagrande: Die Aräometer-Methode zur Bestimmung der Kornverteilung von Böden. Berlin (1934).
11. P. Rosin, E. Rammler, and W. Intelmann: Grundlagen und Grenzen der Zyklonentstaubung. *Zeit. des Vereines Deutscher Ingenieure* (1932) **76**, 433–437.
12. L. C. Whiton: Performance Characteristics of Cyclone Dust Collectors. *Chem. and Met. Eng.* (1932) **39**, 150–151.

New York Talcs, Their Geological Features, Mining, Milling, and Uses

By A. E. J. ENGEL*

Introduction

The New York talc deposits of commercial importance are in St. Lawrence and Lewis counties, in the northwest Adirondack Mountains (Fig 1). All of the deposits are of pre-Cambrian age and occur within highly deformed and recrystallized marble of the Grenville series.

The deposits in St. Lawrence County, near Gouverneur, are the largest and most productive of their type known in the Western Hemisphere. In 1948 the seven mines which are in operation will produce about 130,000 tons of ground talc.

All talc production in Lewis County is from one mine. There the annual production ranges from 15,000 to 30,000 tons.

These so called talcs of New York State include earth materials of different chemical and mineral compositions. In general the mineral talc is subordinate in amount to other minerals in both the Gouverneur and Natural Bridge deposits.

In the Gouverneur district the mineral talc comprises less than 25 pct of the mined and ground rock. Most of the rock mined is a tremolite- or tremolite-anthophyllite schist somewhat altered to serpentine and talc.

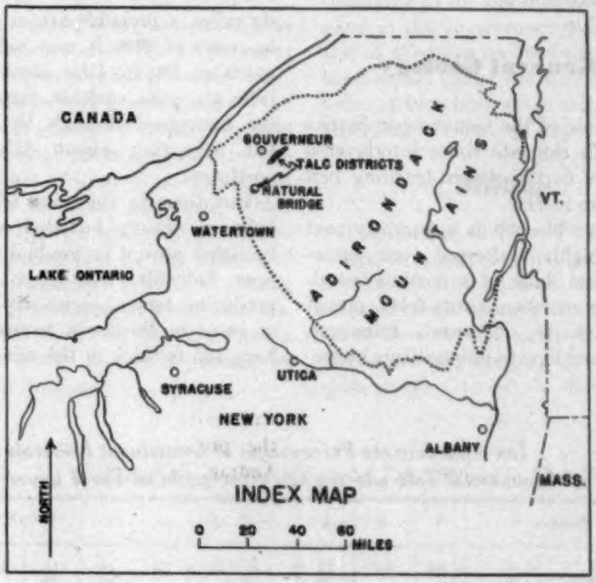

FIG 1—Map of New York talc deposits in the Adirondack Mountains.

Los Angeles Meeting, October 1948. TP 2653 H. Discussion of this paper (2 copies) may be sent to *Transactions* AIME before Oct. 30, 1949. Manuscript received Dec. 7, 1948.

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This characteristic in no way devaluates the "talc" for certain markets, and in some instances makes the material more desirable.

The Natural Bridge talcs include types high in serpentine, as well as complex aggregates of serpentine, talc, carbonates, and diopside.

Usage of the term talc, however, for

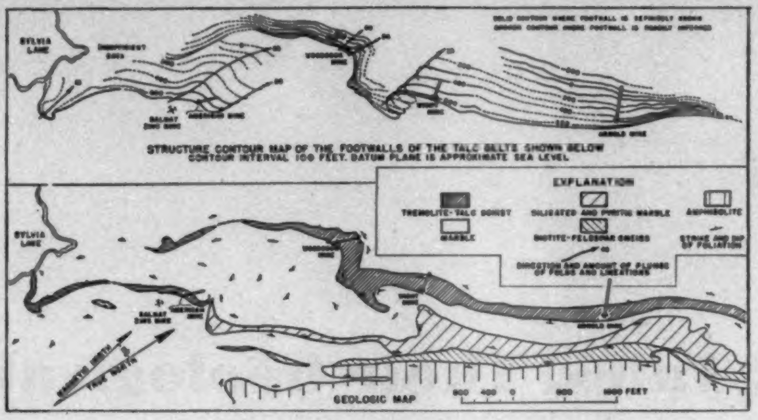

FIG 2—Geological features of the area north of Balmat, N.Y.

these industrial mineral aggregates is widespread and deeply rooted. Accordingly, this usage is followed in this paper. The phrase "the mineral talc" is used herein wherever reference is made to the specific mineral talc, $H_2Mg_3(SiO_3)_4$ or in terms of oxides $H_2O{\cdot}3MgO{\cdot}4SiO_2$.

General Geology

The talc of the Gouverneur district occurs in elongate zones interlayered within a northeastward-trending belt of impure marble.

The marble belt is apparently part of a highly deformed and metamorphosed flank of a northeastward-trending anticline. Cross folds, plunging north to northwest, foliations, shears, and lineations constitute important structural features of the talc zones (Fig 2 and 3).

The zones of commercial talc pinch, swell, and curve in sinuous to complexly folded patterns, Fig 2, but are rudely conformable with adjoining marble layers. The talc zones have a composite strike length of more than six miles, a probable extent down dip in excess of 2000 ft, and widths of as much as 400 ft. Dips along the talc belts are quite variable, ranging from the horizontal through the vertical, but averaging about 45° to the northwest.

Variations in thickness of the talc belts or of any included zone may be either abrupt or gradual. The belt near Talcville, which contains two producing mines, varies up to 300 ft or more in thickness, averaging perhaps 135 ft thick in the mines, Fig 3. Much of this thickness is commercial talc. A talc belt north of Balmat and southeast and east of Fowler, along which are 4 active mines, varies up to at least 425 ft in thickness, and averages possibly 125 ft thick, Fig 2. In this belt, however, one or several zones of commercial talc 6 to 25 ft thick or rarely as much as 75 ft thick are interlayered with impure or discolored noncommercial zones within the belt. Within these two belts are talc reserves sufficient to last several generations, at the present rate of production, under resourceful mining methods.

The approximate percentages of constituent minerals in various types of commercial talcs from the Gouverneur district are shown in Table 1.

A wide variation in proportions of tremolite, anthophyllite, serpentine, and talc are apparent. Other minerals which occur in and along the talc belts include quartz, calcite, dolomite, hexagonite (a manganese-bearing tremolite), iron and manganese oxides, diopside, chlorite, pyrite, mica, feldspars, titanite, magnesian- and manganese-bearing tourmalines, and apatite. Most of these last-named minerals constitute obvious adulterants or impurities and are avoided in mining.

The chemical compositions of some of the more important types of talc are indicated in Table 2. The range of variations in SiO_2 and MgO are readily apparent. Iron and manganese oxides, SO_3, and CO_2 when present in excess of the amounts shown constitute serious impurities for some markets. In general the companies in the Gouverneur district attempt to keep the CaO content between 3 and 7 pct, and the MgO content between 25 and 30 pct. The relatively high CaO content is largely a reflection of the lime present in tremolite and anthophyllite, Table 3.

Much of the tremolite probably formed by reactions between, and replacement of, favorable beds of quartzite and dolomite. This initial stratigraphic control of talc distribution was partly obscured, and to some extent superseded, by prominent secondary structures, especially shear zones that developed during metamorphism.

The talc-forming constituents doubtless were derived largely from the quartzite and dolomite beds, but water, silica, magnesia, and other elements were introduced into the present talc belts, and calcite removed by hydrothermal solutions.

Table 1 . . . The Approximate Percentages of Constituent Minerals in Layers of Commercial Talc and the Oil Absorption of These Layers

Specimen Number[a]	1	2	3	4	5	6	7	8	9	10
Tremolite	68	98	17		78	38	29	15	88	46
Anthophyllite			20				45	78	4	39
Talc, fibrous		1	63					5		
Talc, foliate					>4			1		5
Talc, shredded aggregate								1	1	>4
Serpentine, massive		1		80	18	54	21		4	
Serpentine, fibrous							5			
Quartz	31	trace							2	4
Carbonates	1			2	trace	4				1
Hexagonite, iron and manganese oxides, mica, other impurities	trace			trace						1
Diopside				18		4			1	
Oil absorption 97.5 particles through 325 screen	29	33	58	56	45	50	55	52	35	48

[a] 1. Pale-pink, tremolite schist, hanging-wall side of talc belt, Talcville, N. Y.
2. Lustrous, white, stubby-bladed tremolite rock interlayered with Specimen No. 1.
3. Pale-gray to white, fibrous "talc," Talcville, N. Y.
4. Watery-green, serpentinized diopside rock along footwall talc belt, Talcville, N. Y.
5. Serpentinous tremolite, "10A ore," Talcville, N. Y.
6. Streaked, buff to chalky-tan, serpentinous tremolite, "regular ore," Talcville, N. Y.
7. Watery-gray, fibrous to bladed, tremolitic talc, Ontario mine, Fowler, N. Y.
8. "Arnold fiber," Arnold mine, Fowler, N. Y.
9. Medium-grained, serpentinous, splotched tremolite, "Arnold heavy stock," Arnold mine, Fowler, N. Y.
10. Pale buff, highly schistose "talc," hanging-wall zone, Woodcock mine, Balmat, N. Y.

Talc Mining

In general, methods used in mining New York talcs are less progressive than those used in the zinc mines of the same region.[1,2] Until recently, less than 30 pct of the commercial talc in the larger deposits was recovered. The amount of talc recovered from smaller, complex zones and ore bodies was considerably smaller. In general, however, and especially at Natural Bridge, N. Y., numerous natural obstacles in the way of efficient operations are presented by complexities of form, structure and composition of these talc deposits. At present, capable operators, who have introduced modern equipment, are in charge in most of the New York mines, and the projected plans of the several companies, if effected, will result in a more ideal exploitation of the important talc deposits.

Both the tabular deposits of the Gouverneur district and the brecciated talcose marble at Natural Bridge have a moderate to steep dip. In these deposits it is common practice to sink a shaft in the talc, on the footwall side of the desired rock. Since the commercial talc is followed by most of the shafts, changes in dip and plunge of the talc body are reflected in corresponding irregularities of the shafts. One straight, inclined shaft was sunk in 1934 in the Gouverneur district, and another vertical, concrete-lined shaft is being sunk at present to an adjacent talc body.

In most of the New York mines, drifts and crosscuts driven from shafts are used to explore and outline the body of minable rock, as well as for tramways and subsequent mining needs. Since many deposits are of irregular, folded forms, many drifts are quite crooked. Almost no timbering is done in the Gouverneur district. At Natural Bridge, steel and concrete are employed in the shaft where it cuts a major fault zone, but the drifts are not timbered. Caving and bad ground constitute serious problems, however, in both districts.

In the Gouverneur district it is common practice in mining the talc bodies to drive raises at frequent intervals, often 30 to 50 ft, in whatever minable talc is encountered, as far as the overlying levels, or as far as safety or the upper limit of the talc body permits. Wet drilling is employed exclusively in the New York mines to reduce the hazard of silicosis and fibrosis.[3]

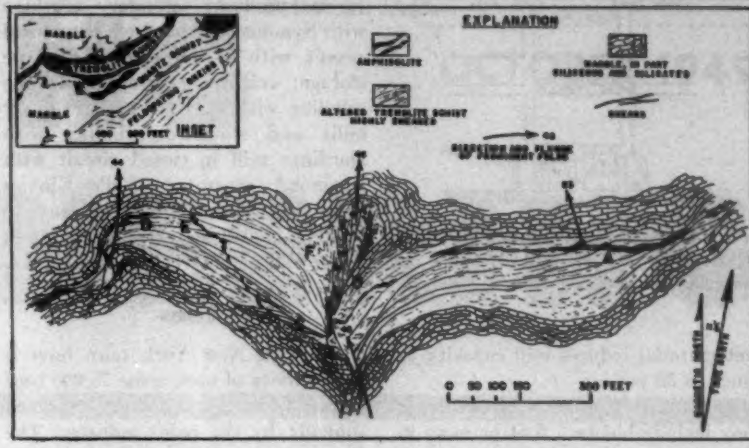

FIG 3—Simplified geological map of the seventh level of the International Talc Co. mine, Talcville, N.Y.

The raises are enlarged into stopes, with the broken rock falling to the drift floor to be mucked by hand or mechanically. A few old stopes in a number of New York mines "work themselves."

Recent practice in the Gouverneur district tends toward the development of conventional sublevel stopes wherever possible, with grizzlies and chutes. A valuable addition is a waterway with a fine-spaced grizzly placed in the intersection of appropriate raises and sublevels to drain off water which would otherwise soak the muck and impede milling (Fig 4). The underhand stoping (benching) method of mining commonly is employed where possible. In several mines in the Gouverneur district, blocks of ore are mined by long hole drilling.

Conventional practice in all the mines involves the use of air and electrically operated mucking machines, commonly rocker shovels, for mucking crosscuts and drifts. Small battery locomotives have supplanted hand tramming in all the mines. One company in the Gouverneur district sorts talc at the mine on steel plates in the head house. Under the steel plates is a series of bins into which talc is sorted according to color and impurities.

Milling

Talc milling in New York, as elsewhere, is largely a grinding operation, accompanied by air separation. Seven talc mills are in operation in New York, six of them in the Gouverneur district. Driers are employed in three of these mills in the Gouverneur district since

Table 2 . . . Chemical Analyses of Industrial Talcs Mined in New York State

Specimen Number[a]	1	2	3	4	5	6	7
SiO_2	59.80	66.23	67.0	56.50	59.40	57.26	47.0
Al_2O_3	0.57	1.05		1.0	0.74	1.14	1.71
Fe_2O_3	0.05	0.13	1.40	0.10	0.02	0.24	
FeO	0.15	0.22			0.12	0.05	
MnO	0.39	0.16	0.80		0.20	0.51	
CaO	6.80	2.26	2.30	6.20	4.94	6.50	6.61
MgO	27.45	25.71	24.80	30.40	30.09	29.08	33.5
TiO_2						0.04	
SO_3	0.07	0.01	0.07		0.01	0.14	
Ignition loss	4.75	3.86	3.10	4.80	4.09	3.98	7.74
Water (105°C)	0.45	0.25	0.30	0.77	0.47	0.34	1.96
CO_2	1.18	0.56	1.30	0.20	0.31	0.29	2.61
Total	101.66	100.44	101.07	99.97	100.39	99.57	101.13

[a] 1. Analysis of average sample of mined talc zone, Talcville, Gouverneur district, N. Y. Analyst Glen Edgington, U. S. Department of Agriculture.
2. Analysis of average sample of footwall talc zone, Fowler, Gouverneur district, N. Y. Analyst Glen Edgington, U. S. Department of Agriculture.
3. Analysis of hanging-wall talc zone, Woodcock mine, Balmat, N. Y. Analyst Orton Smalley, courtesy Loomis Talc Corp.
4. Analysis of footwall zone, American mine, Balmat, N. Y., courtesy St. Joseph Lead Co.
5. Analysis of "middle zone," Woodcock mine, Balmat, N. Y. Analyst Charles O'Brien, courtesy Loomis Talc Corp.
6. Analysis of average sample across commercial talc zone, Balmat, N. Y. Analyst F. A. Gonyer, Harvard University, courtesy R. T. Vanderbilt Co.
7. Analysis of "Micro Velva Talc," Natural Bridge, N. Y., courtesy Carbola Chemical Co.

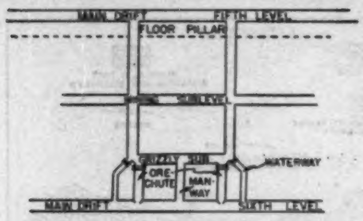

FIG 4—Diagrammatic sketch showing development of an inclined tabular or lenticular talc body by sublevel stopes.

wet material reduces mill capacity as much as 30 pct.

Talc taken from some of the mines may include blocks a foot or more in their largest dimensions. This rock goes directly from the mines to crushing plants at the mills, where primary and secondary crushers are used to reduce the talc to ½, 5/16, 3/16 or ⅛ in. products. Finer grinding is achieved in tube mills, Raymond mills, and Hardinge mills, in closed circuits with Sturtevant, Raymond or other type air separators.

Much New York talc is ground to one of the following general size groups: 97.5 pct particles through a 325 mesh screen, or 99.5 pct particles through a 325 mesh screen. Actually, in achieving either of these specifications, some talc is "overground" with a resulting large spread in particle dimensions. Many fines 15 to 35 microns in size commonly result.

Extremely fine grinding with fluid energy mills is done in several New York mills. A number of Micronizers and Wheeler mills are now in operation. Standard particle sizes ranging between one-half and 20 microns, as measured by air permeation methods, are attained in this fine grinding.

The following mill procedure is contemplated for a mill just erected in the Gouverneur district: primary crushing with gyratory crusher at shaft head house; conveyor to plant 500 ft away; wet storage; drying of minus ⅝ in. product; secondary crushing with Symons shorthead cone in closed circuit with ⅛ in. screen; dry ore storage; weightometer; extremely fine grinding with C. H. Wheeler Co. air mills and standard grinding with Hardinge mill in closed circuit with Raymond separator; Fuller-Kinyon conveying to bulk storage bins to packing house; Bates valve packers; power and gravity conveyors to cars.

Uses

Although New York talcs have a wide variety of uses, some 75,000 tons of talc from the state are employed annually by the paint industry. The fibrous form of the minerals anthophyllite and talc especially seems to hold heavier paint pigments in suspension longer, and to prevent caking and settling. The fibrous and blade-like mineral forms also are believed to serve as locking or bonding agents in the paint film. Better grades of Gouverneur talc have values of 90 or better in the standard industry whiteness scale.

A conventional standard for classifying New York talcs prepared for paints is the Gardner-Coleman oil absorption test.[4] In general, fine grinding increases the quantity of a given oil required to wet thoroughly all the absolute particle surface of the talc. For approximately uniform particle sizes, the talcs composed largely of the mineral talc, or serpentine, have a higher oil absorption than talcs rich in tremolite, quartz, or carbonates. Highly fibrous or flaky grains have greater oil absorption than equant grains of roughly the same size groups as indicated by conventional screening.

New York talcs range from 30 to 60 in the scale of oil absorption. The slightly serpentinous or talcose tremolite schist so common in the mines of the Gouverneur district tests between 40 and 45 when ground so 97.5 particles will pass through a 325 mesh screen. Essentially unaltered tremolite, ground to about the same size averages between 30 to 34 in oil absorption, Table 1. This same tremolite rock, ground to grain sizes of 1 to 25 microns, tests about 40 to 42 in oil absorption. Obviously the extent of surface area in relation to the mass of the grain is an important factor in determining oil absorption.

The ceramic industry used about 25,000 tons of New York talc in 1947, and probably will use a larger tonnage in 1948. In the manufacture of whiteware bodies, the CaO content of 4.5 to 6.5 which characterizes much Gouverneur talc is not at all objectionable, and in fact, may be desirable.[5]

Besides the consumption of New York talc in the paint and ceramic industries, appreciable tonnages are used in the insecticide, rubber, and textile industries.

In general, consumer demand has and continues to be for a talc of uniform chemical and physical properties. Accordingly, present philosophies in the two New York districts are to establish practical and efficient means of blending and averaging out the variations along and across the strike and down dip inherent in the talc deposits.

Acknowledgments

The writer's studies of New York talcs were undertaken for the U. S. Geological Survey, and welcomed and enlivened by the staffs of mining companies in the New York districts.

I also wish to acknowledge the inestimable contributions to my efforts made by H. M. Bannerman, C. N. Bozion, A. F. Buddington, James Page and many other members of the U. S. Geological Survey.

References

1. John S. Brown: Geology and Exploration at the Edwards and Balmat Mines, N. Y. *Min. and Met.* (Aug. 1947) 387–389.
2. M. G. Jones: Mining Practice at the Edwards and Balmat Mines. *Min. and Met.* (Aug. 1947) 390–394.
3. W. Siegal, A. R. Smith, and L. Greenberg: The Dust Hazard in Tremolite Talc Mining, Including Roentgenological Findings in Talc Workers. *Jnl.* Amer. Roentgenology and Radium Therapy. (Jan. 1943) 49 (1) 11–29.
4. H. A. Gardner and Levy Stanley. Scientific section, Amer. Paint and Varnish Mfgs. Assn. (1929).
5. D. Hager: Effect of Tremolitic Talc in Wall Tile Bodies. *Jnl.* Amer. Ceramic Society (Jan. 1936) 19 (1) 14–23.

Table 3 . . . Approximate Composition by Oxides of the Common Minerals in, and Associated with, Industrial Talcs of New York

Mineral	CaO	MgO	Al_2O_3	SiO_2	CO_2	H_2O	MnO
Talc		32		63		3–7	
Serpentine		43		44		7–13	
Chlorite		36	18	33		5–14	
Tremolite	13	27		57		2	
Anthophyllite	3.5	31	0.5	59		2.5	3
Diopside	26	18		56			
Dolomite	30	22			48		
Calcite	56				44		
Quartz				100			